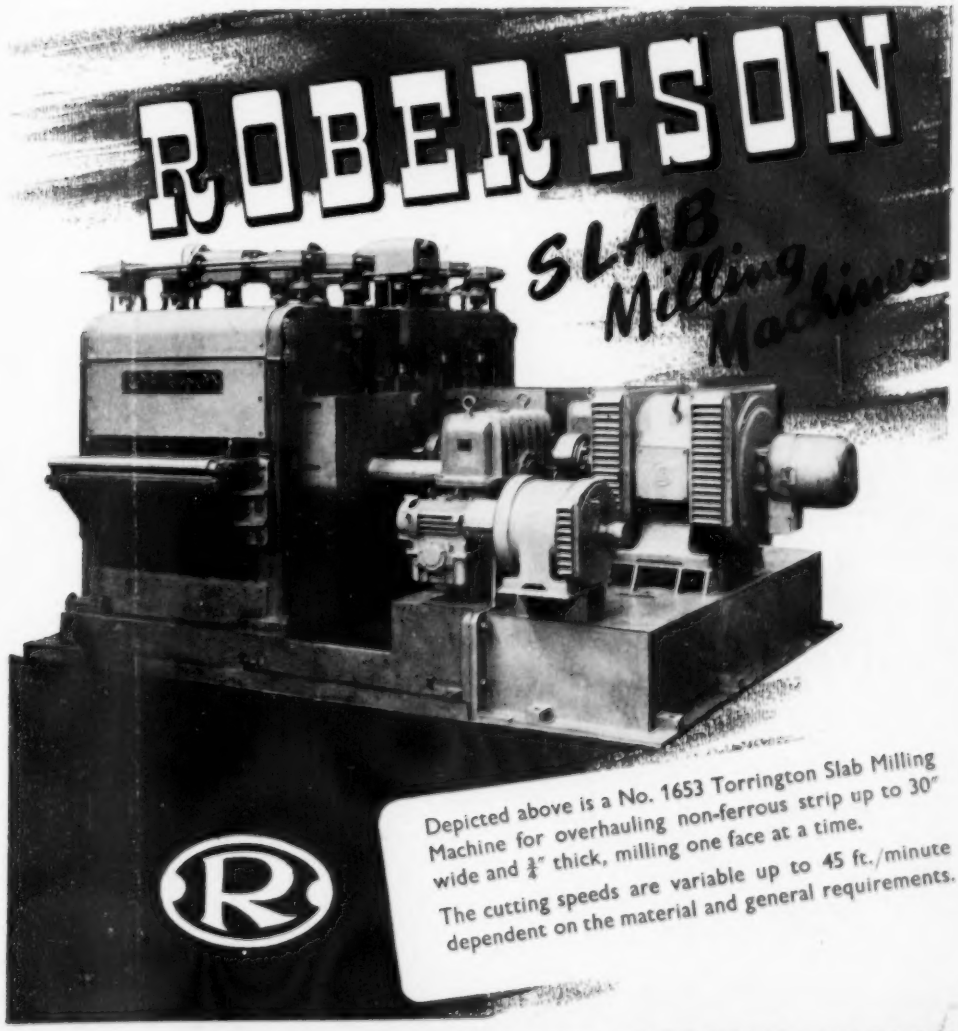
Sheet Metal Industries

The only Journal in the World wholly devoted to the Manufacture, Manipulation, Fabrication, Welding, Assembly and Finishing of Ferrous and Non-Ferrous Sheet and Strip

VOL. 37 : No. 395 MARCH 1960 PRICE 2/6



Depicted above is a No. 1653 Torrington Slab Milling Machine for overhauling non-ferrous strip up to 30" wide and ¾" thick, milling one face at a time.

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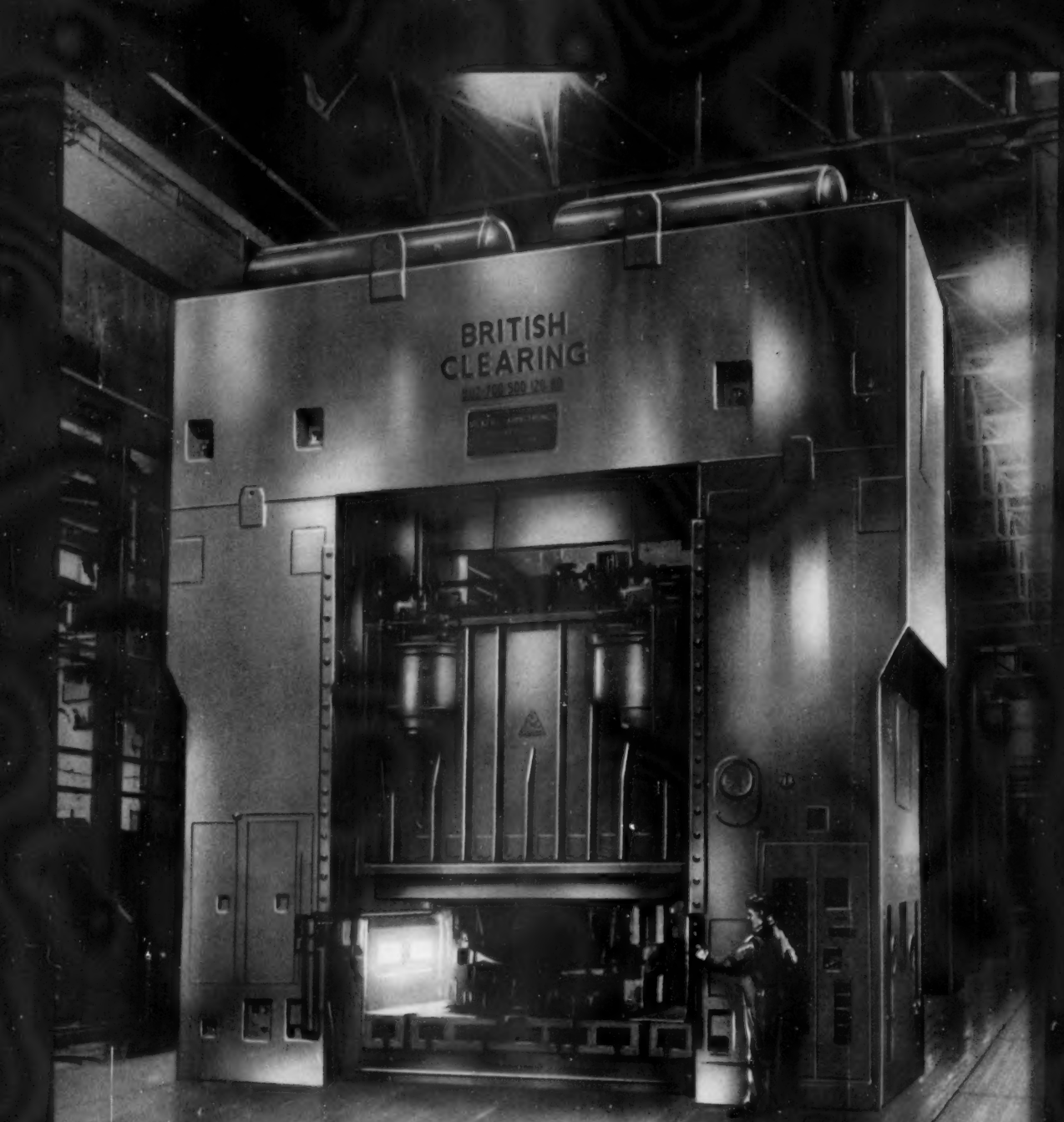

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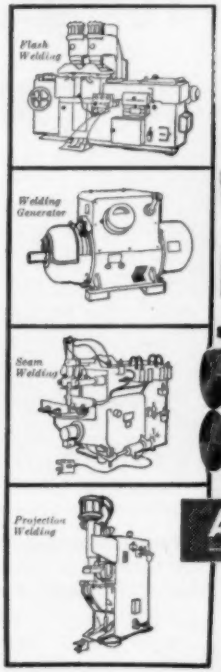

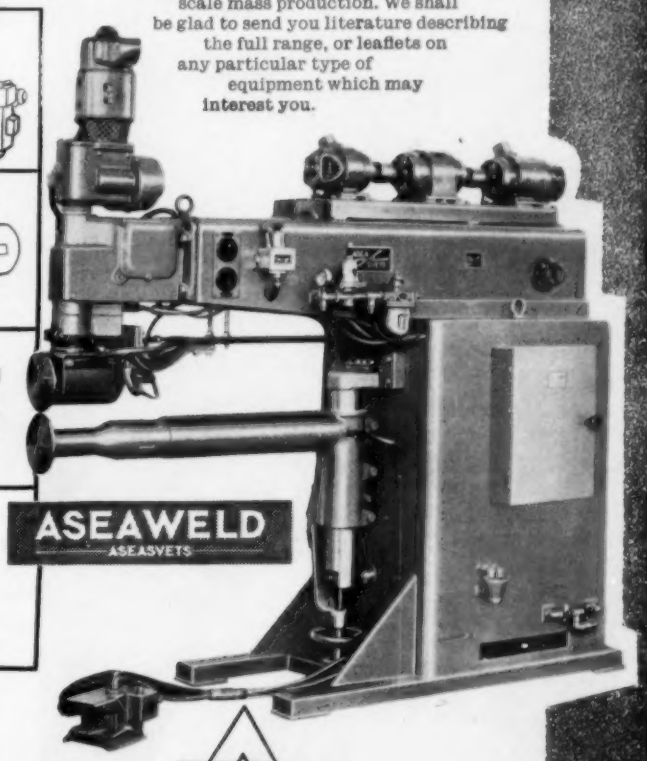

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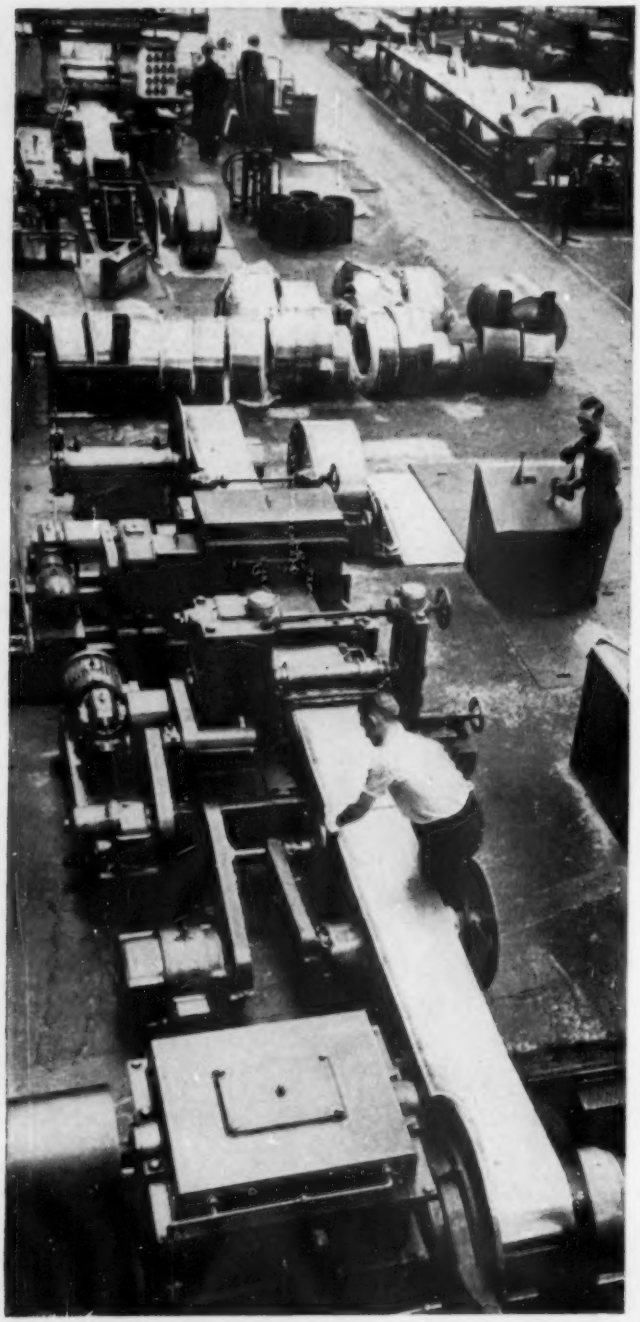
Editorial Contents. page 161 **Classified Advertisement pages. 109**



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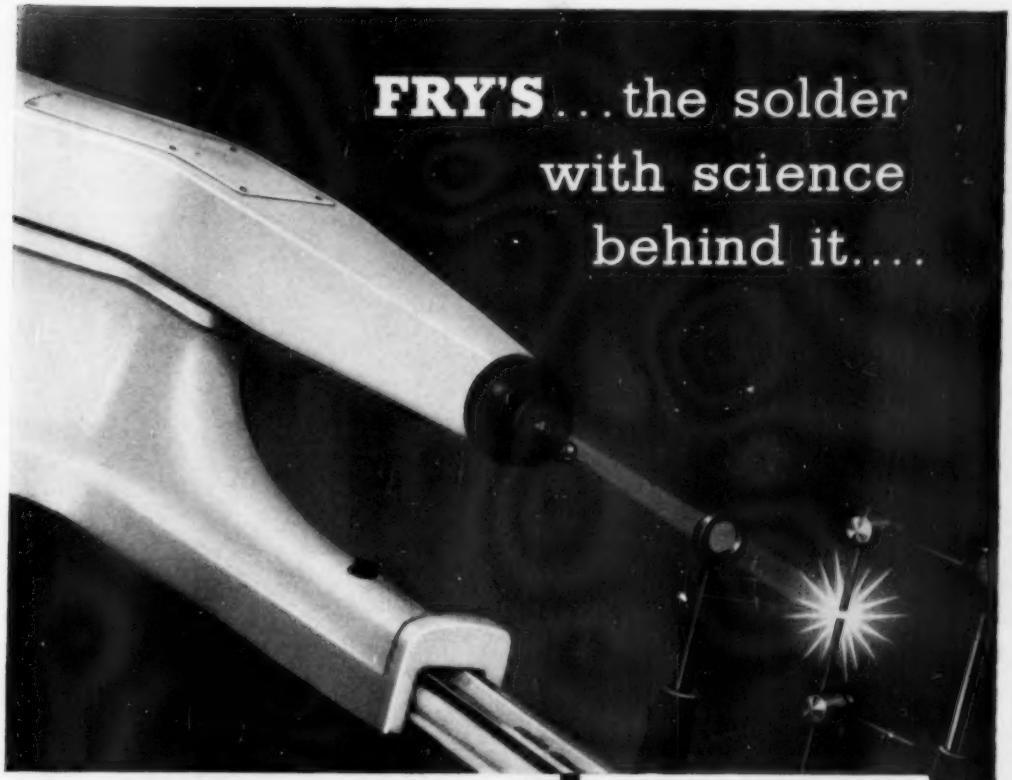

This is a routine spectrographic test carried out on every batch of FRY'S solder which leaves the works.

The spectrographic test detects harmful impurities which could mean gritty solders causing weak or brittle joints.

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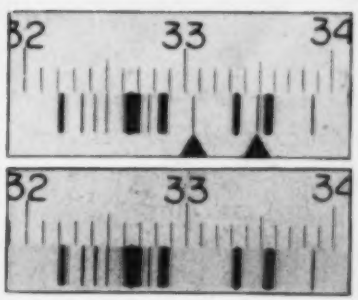

★

Spectrographic Tests Prove it!

In this top print the fine lines (arrowed) show zinc impurities which mar performance. The print below is free from contaminating impurities typifying FRY'S solders.

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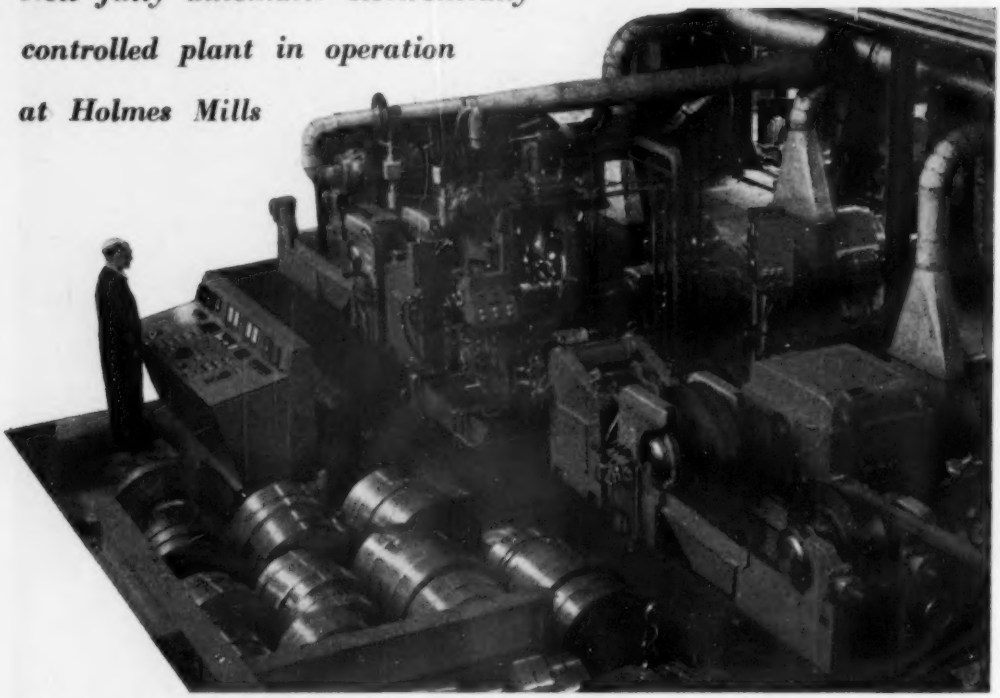

Now you can depend even more on the traditional 'quality in quantity' of Habershon steel strip. Faster production: micro-measurements more consistent than ever before: tolerances even closer than those required by the strictest specification—all this is made possible at Habershons by the recent installation of completely automatic plant.

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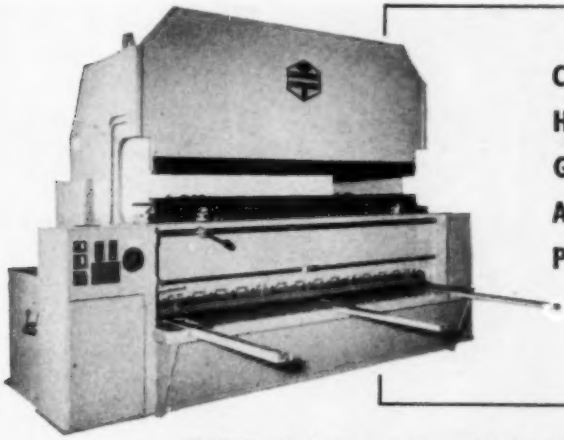

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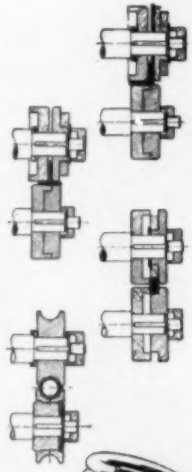

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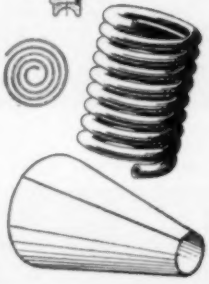
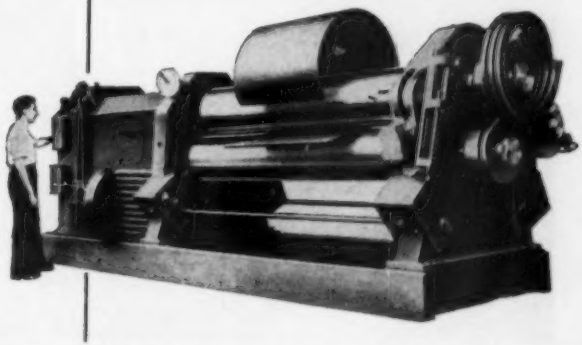
SECTION
BENDING
ROLL
OF
INITIAL
PINCH
TYPE





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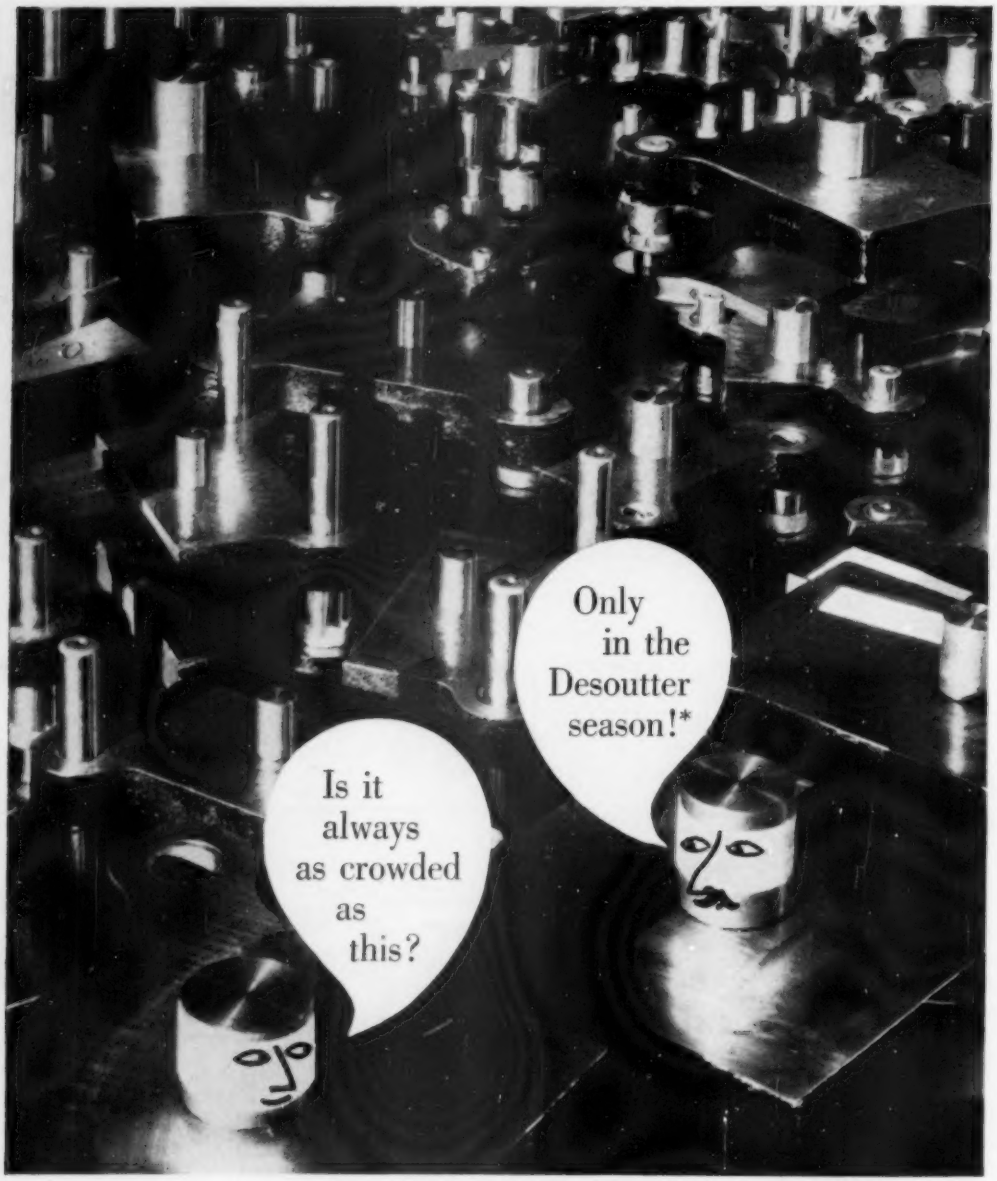

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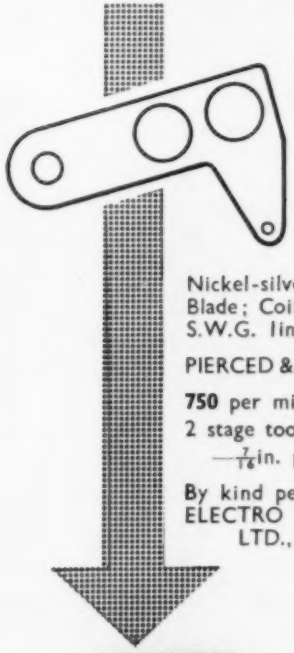

Nickel-silver Contact Blade; Coiled Strip 28 S.W.G. 1in. width.

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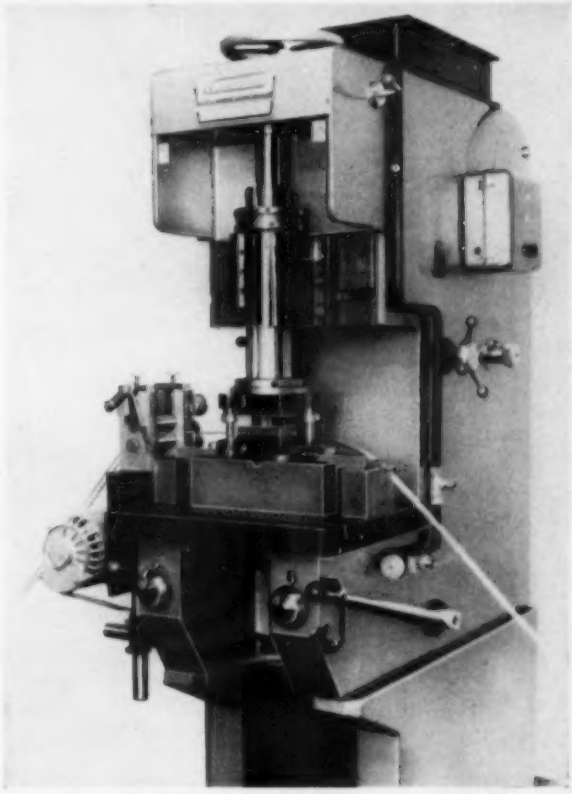

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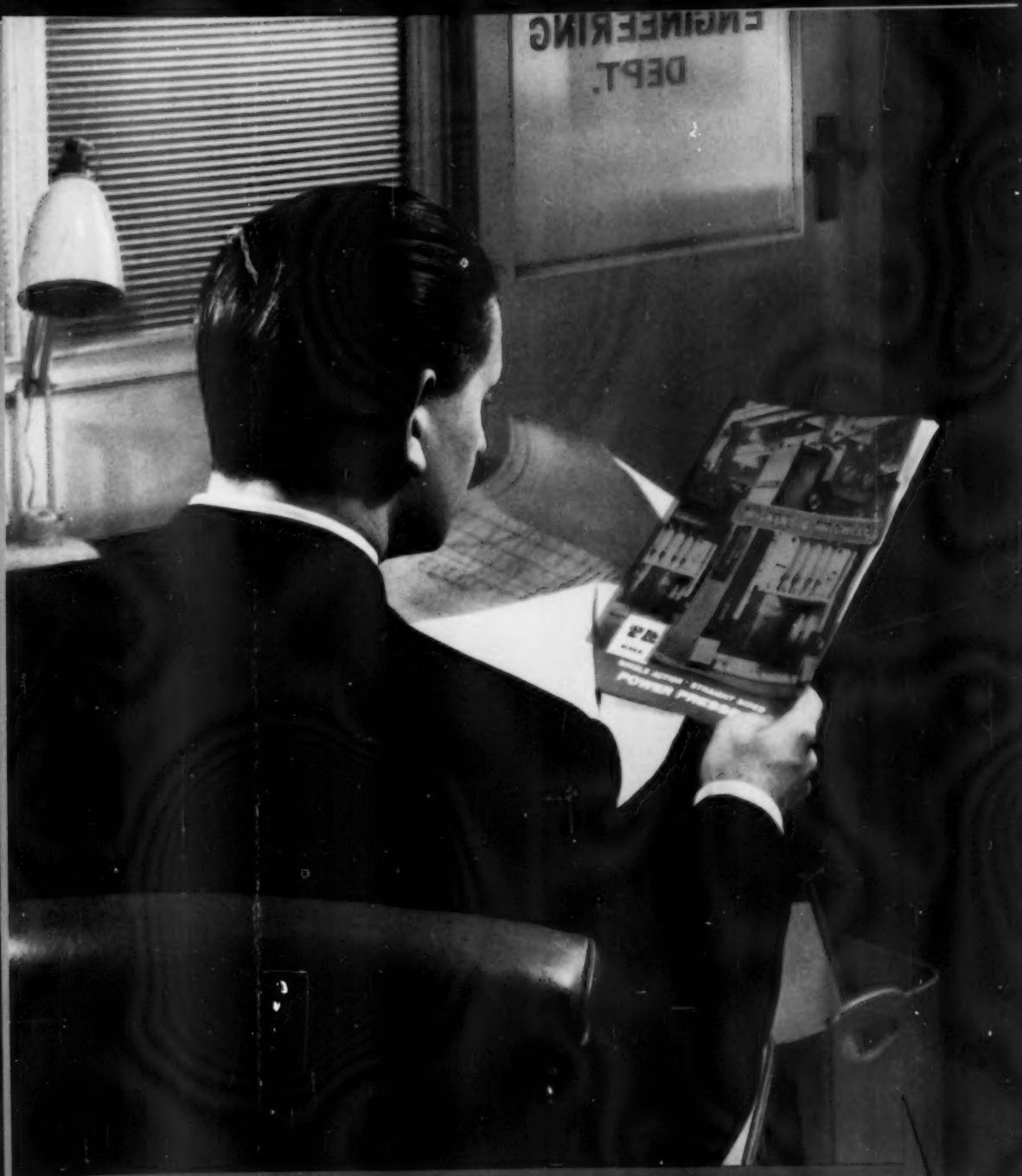

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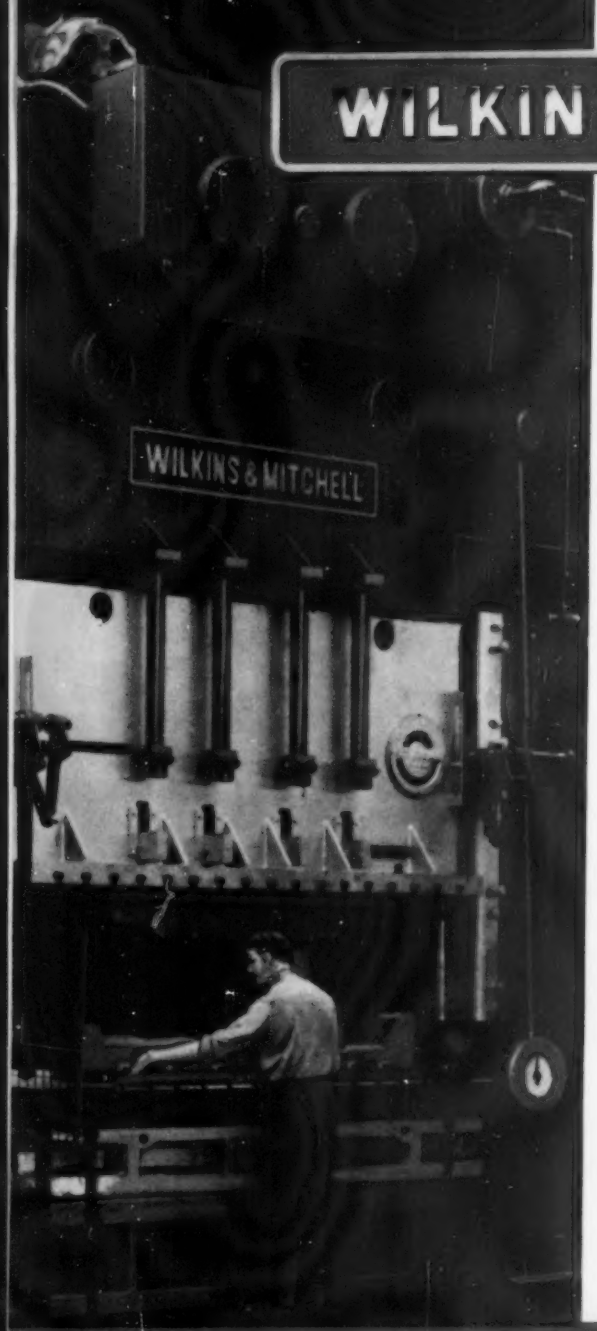

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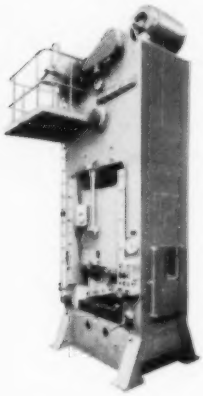

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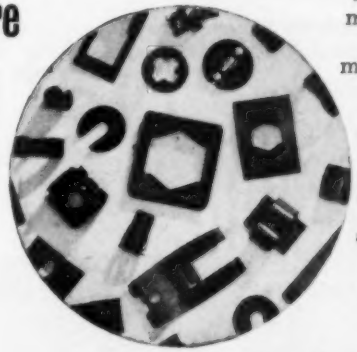
did you know that there are now more than 600 Spire Speed Fastenings



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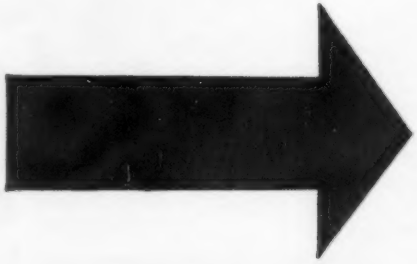
Steel's first 'Report to the Nation'

The British Iron and Steel Federation is adopting a new approach to the public in a series of advertisements in the national and provincial press entitled REPORT TO THE NATION. These advertisements, as they appear, will deal with current news of the steel industry. The first report is concerned, among other things, with the industry's production record and development plans; with some of the latest uses of steel; and with the social conditions of workers in a typical steel producing area. Future reports will explore other sides of the industry: the personalities running it; research activities; management training.

The first report has already appeared. It will be followed by others at intervals during the year, and almost everyone in the country will have a chance to see them. In this way, people can learn not only how a vital industry operates, but also how closely the prosperity and everyday life of the nation is bound up with that of Steel. The Reports will be important, too, in helping those within Steel to know it better, and to realise they're part of an efficient, progressive and booming industry.



STEEL – NEW YL... TO THE N...

HOW MUCH STEEL IN 1960?

THE British steel industry may well produce about 24 million tons of steel in 1960—compared with 20 million tons last year.

Last year, and the year before, the steel industry spent some £100,000,000 on new plant and development—and raised its production capacity by about a *million* tons each year. This was done despite the fact that existing capacity, except in a few cases, was not being fully used.

Why this expansion, then? Is it an act of folly—or farsightedness? It is simply an expression of confidence in Britain's future.

Apart from the sharp set-back around 1958, when the industry was working far below capacity, demand for steel has shown a steady upsurge since the war. Looking forwards, the industry has weighed forecasts made by its customers about their future demand.

As a result the industry believes that the trend of steel demand will continue to rise.

Planning ahead in Steel is a ticklish business. It means foreseeing future developments in the economic life of the nation, and the changing needs of steel consumers.

Among the thousands of steel-using firms the pattern of demand can change almost overnight. But planning, building and bringing into production a new steelworks inevitably takes years.

UNEXPECTED

A plant making rails cannot change over to production of sheet for cars.

Hence in the past two years, although the steel industry as a whole has not been working at full capacity, there have sometimes been shortages of steel sheet.

Why? The causes were an unexpectedly swift boom in cars - which took even the motor industry itself by surprise - rising sales of household goods like cookers and washing machines, and of electrical machinery; and a shift in demand from one kind of steel sheet to another.

£760 MILLION

Not even the wisest brains can predict, years ahead, every future shift in the pattern of demand. But Britain's steel industry has done remarkably well since the war in having the right plant ready at the right time.

Since the end of 1946, a sum of over £760,000,000 has been spent on development. The graphs show the crescendo of expansion in the last seven years; and also how the steel industry, far from lagging, has gone ahead faster than other manufacturing industries.

NEW MILLS

In the critical field of cold reduced sheet, production in 1959 was 13% up on 1956, and will rise again by perhaps as much as 20% in 1960. Further expansion at existing strip mills and construction of two new mills at Newport and Ravenscraig, work on which is being accelerated, will meet the likely demand for sheet and tinplate.

What of the other sections of the industry? Although hit by the recession, they have pressed on with expansion. The new Universal Beam Mill at Lackenby, best of its kind in the world, is in production - indeed, everywhere the nationwide programme of steel development is accelerating. At the lowest point (December, 1958) the industry was operating, on average, at about 70% of capacity. Now the rate is over 90% - of a greater capacity.

UP AND UP

Prospects are that there will still be some margin of capacity in 1960 in certain heavy steel products, as a result of continued slackness of demand from railways, coal mines, and shipbuilders. But demand for other types of steel is expected to rise still further.

Steel production in 1960 may therefore be between three and four million tons more than in 1959.

Continued modernisation and expansion - at a cost of over £100 million a year - will provide an efficient steel capacity of over 30 million tons by 1965, a sound basis for competing in world markets.

SIXTY KINDS OF STEEL ON T...

Steel takes these shock

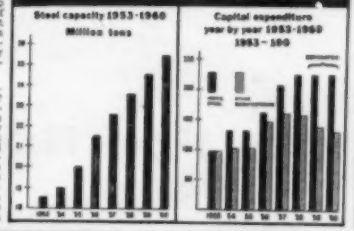
THEY do brutal things to a car, down at Nuneaton, on the proving grounds of the Motor Industry Research Association. And every time they test a car, sixty different kinds of steel are on trial. That's how many there are in a modern car.

One of the tortures have devised consist pave track made of stone blocks, set angles, with pier pot-holes. They le drive cars across it.

And what bears brunt of this savage

Fifty

SEVEN YEARS OF STEADY PROGRESS



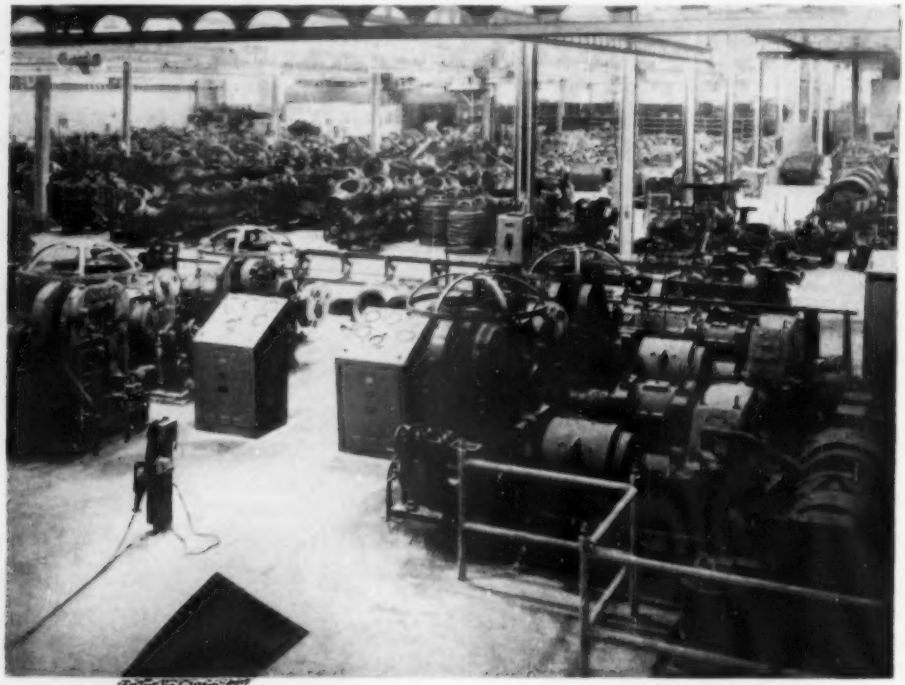
New life in the Valleys

BY TREVOR EVANS

THE "black years" of the twenties and thirties are not yet forgotten in South Wales. So it was with deep misgivings that I went back to the village where I grew up.

I was never so surprised in my life. I rubbed my eyes, thinking for a moment that I had strayed into the wr...

THE BRITISH IRON AND STEEL FEDERATION



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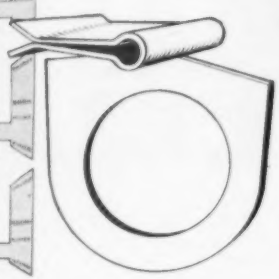
CCW

PUNCHING TOOL-STEEL



CCW provides a notable combination of hardness and toughness making it an excellent shock-resisting tool steel for cold punching work. Amongst its many uses are press and forming tools, tin-can dies and rings, casement tools for mild steel and cold heading dies.

A useful degree of red hardness at elevated temperatures has led to CCW being used also for hot heading dies, forming and piercing tools and purposes where short contact with hot metal involves only restricted rise in tool temperature. Very clear printed data on this steel is available upon request.

Heavy punches
Press and forming tools
Tin-can dies and rings
Casement tools for mild steel
Caulking and bending tools
Cold heading dies
Hot heading
Forming and piercing tools

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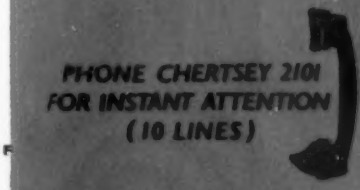

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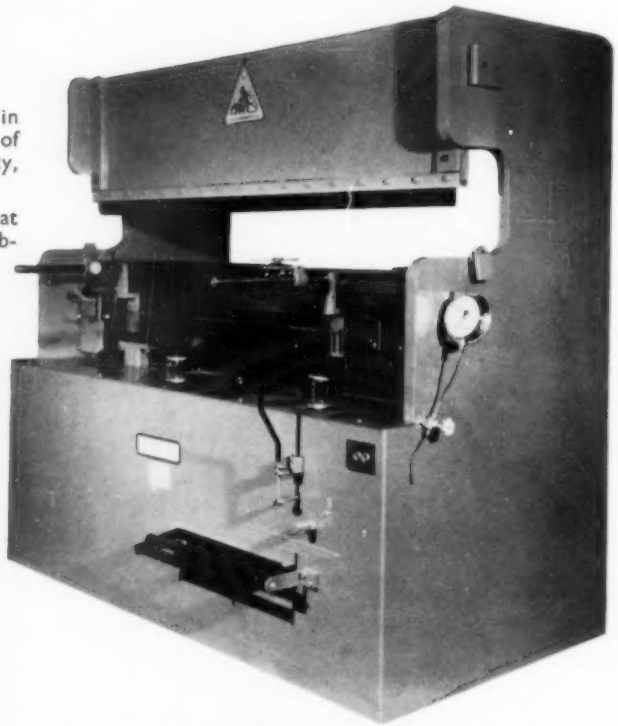
These Barnes Presses are universal in their application — any thickness of material, within the rated capacity, may be worked without resetting.

The Barnes Press is an open Throat Design constructed sturdily of fabricated steel plate and sections, with a hydraulic unit built in.

Included as standard equipment are a multi-groove die, a 90° punch and adjustable gauges.

RATED CAPACITY IN MILD STEEL 28 ton tensile	PRESSURE IN TONS	LENGTH OF STROKE
4' 0" × ¼"	56	0 - 8"
8' 0" × ⅛"	56	0 - 8"
8' 0" × ⅛"	70	0 - 12"
6' 0" × ¼"	70	0 - 12"
8' 0" × ¼"	105	0 - 12"
10' 0" × ¼"	140	0 - 12"
12' 0" × ¼"	168	0 - 12"
6' 0" × ⅜"	105	0 - 12"
8' 0" × ⅜"	140	0 - 12"
10' 0" × ⅜"	160	0 - 12"
12' 0" × ⅜"	192	0 - 12"
6' 0" × ½"	140	0 - 12"
8' 0" × ½"	175	0 - 12"
10' 0" × ½"	225	0 - 12"
12' 0" × ½"	270	0 - 12"



One of our Technical Representatives will gladly visit you, on request, to discuss your problems.

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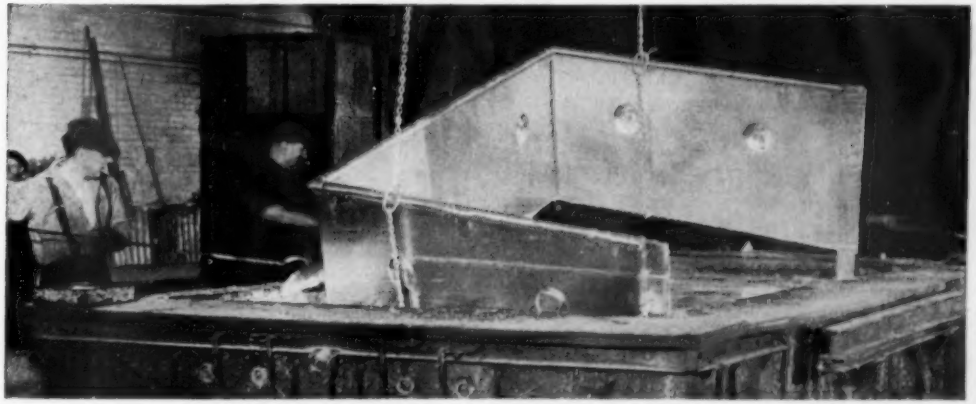

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It SAVES STEEL by eliminating the need for large corrosion allowances and the replacement of rusted parts.
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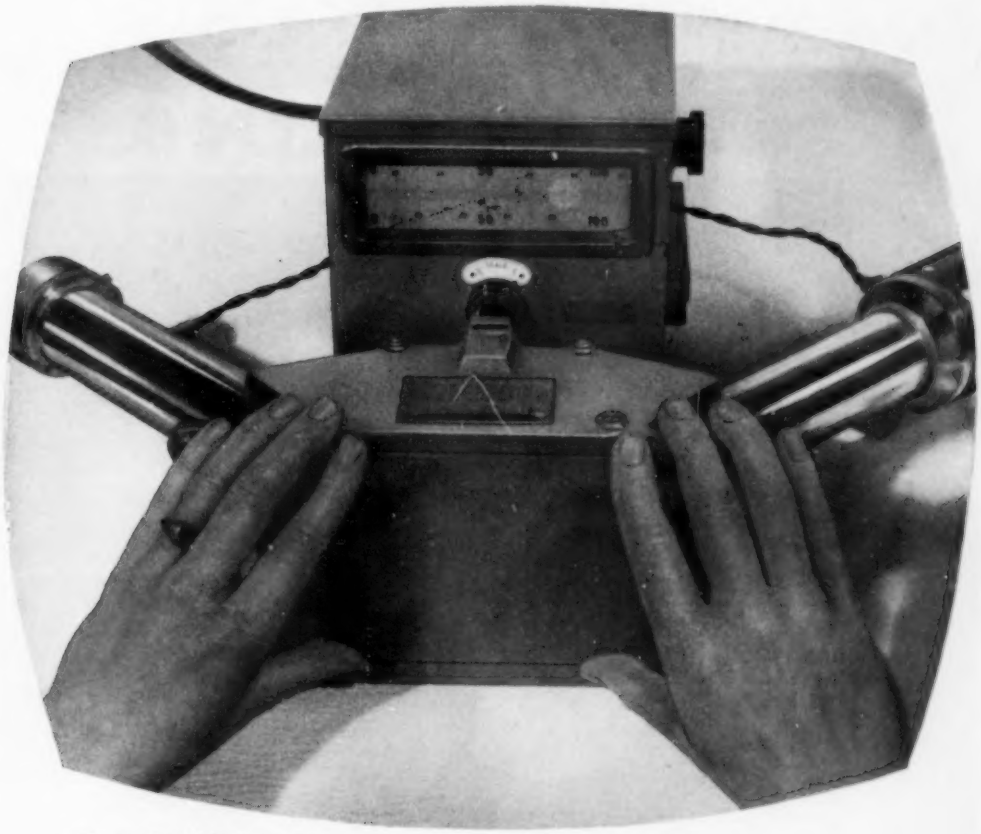

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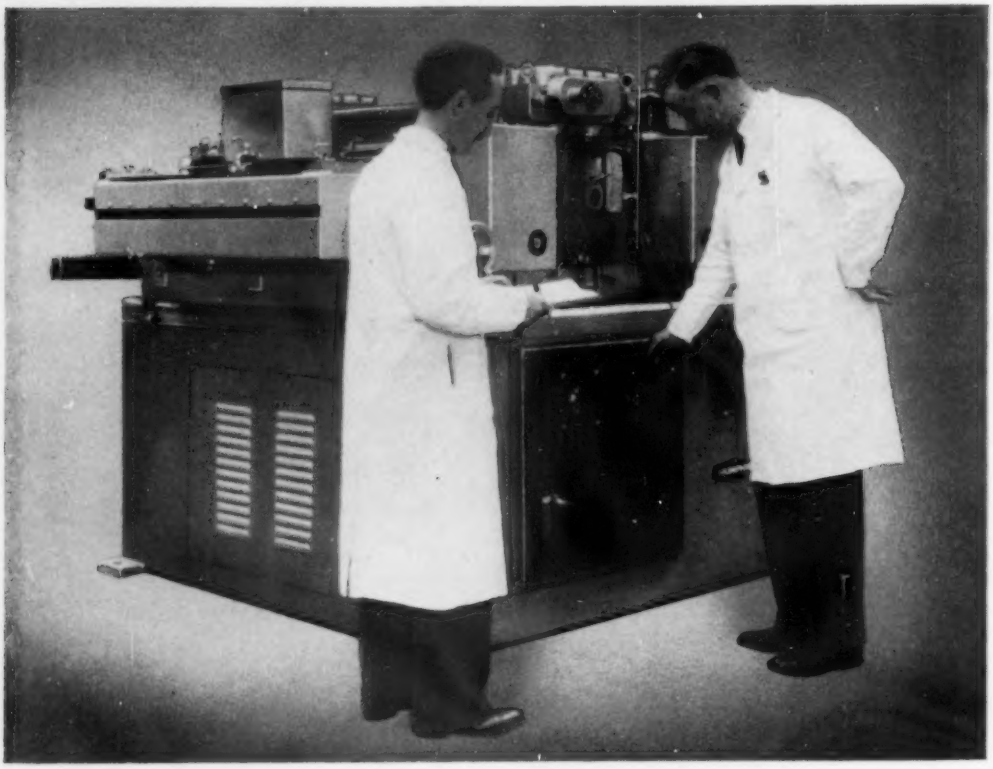

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This new development combines in one machine the functions of strip levelling and press feeding. Here is an entirely new approach to an old problem in connection with which we shall be making future announcements in this journal.

pressmaster

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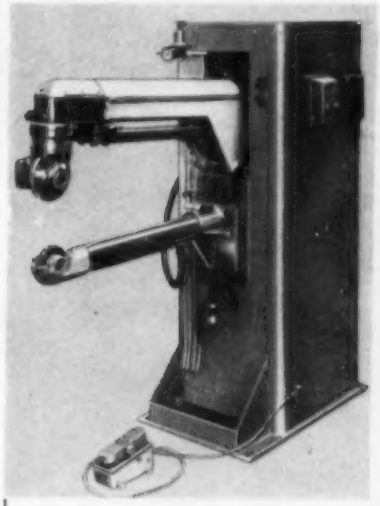
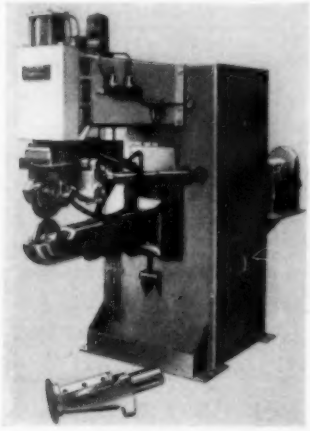
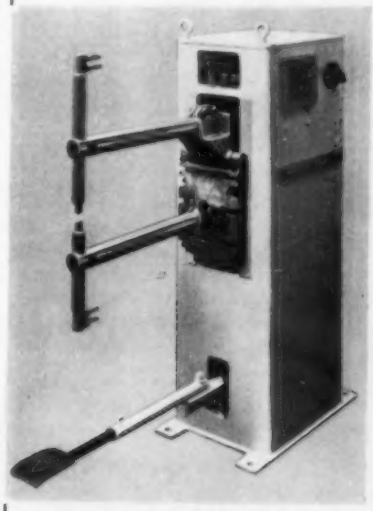


40 KVA Rocker arm type Universal Seam Welder.



Heavy duty 300 KVA Universal Seam Welding Machine with provision for step-by-step or roller spot welding.



Pedal operated Rocker arm type Spot Welder with electronic weld timer.

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AEI ELECTRONICS DATA SHEET
Subject IGNITRONS — RATINGS

Welder types

Types	Maximum Demand* (kVA)	Maximum average* anode current (Amps.)	Temperature control
BK 22	450	15	—
BK 24	1200	140	—
BK 24A	1200	140	Integral
BK 24B	1200	140	Clamp on
BK 34	2400	355	—
BK 34A	2400	355	Integral
BK 34B	2400	355	Clamp on
BK 42	600	56	—
BK 42A	600	56	Integral
BK 42B	600	56	Clamp on
BK 66	300	22·4	—

* Ratings are for welder control service and refer to two valves in inverse parallel at any voltage from 250-600v. r.m.s.

Rectifier types

Type	Maximum peak voltage (Kilo volts)	Maximum average current at peak voltage (Amps.)
BK 44	2·1	75
BK 46	2·1	150
BK 56 ‡	20·1	150

‡ Tentative ratings.

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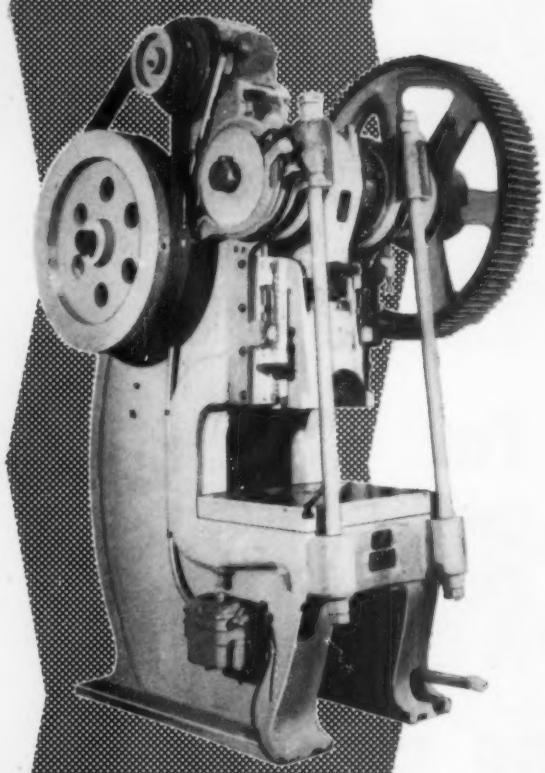
SMI/564/X21

Open-fronted presses



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The Butterley range of sheet metal machinery includes geared and ungeared power presses, guillotine shears, press brakes and general machinery for the hot and cold working of metals.

All castings are made by the "Meehanite" process in our own well-equipped foundries. The Butterley foundries are available for the production of high-grade "Meehanite" castings to customers' requirements. We invite your enquiries for "Meehanite" castings of all grades up to 20 tons.

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100-ton geared open-fronted press with wheel guards removed.

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STEEL SHEETS

plus COLOUR plus TEXTURE

'Artbrite' sheets are RTB M.S. sheets (protected by hot-dip 'Speltafast' galvanizing or by lacquering) with a closely-adherent 10 thou. coating of P.V.C. film.

Available in many luxury finishes, glossy, matt, and various textures, and in a wide range of colours, the coating is resistant to abrasion and to a great many chemicals. 'Artbrite' sheets on the 'Speltafast' base are fully weather-resistant.

EXTRAORDINARY 'WORKABILITY'. 'Artbrite' sheets can be pressed, drawn, bent, seamed, formed and riveted—even welded, without disturbing the adhesion of the P.V.C. For all intents and purposes, this will stand up to everything that the steel sheets will stand. In sheets up to 48" wide, gauges 16 to 26 b.g. inclusive, at competitive prices.

This cupping test piece shows the elasticity and adhesion of the P.V.C. coating, and retention of the surface texture.

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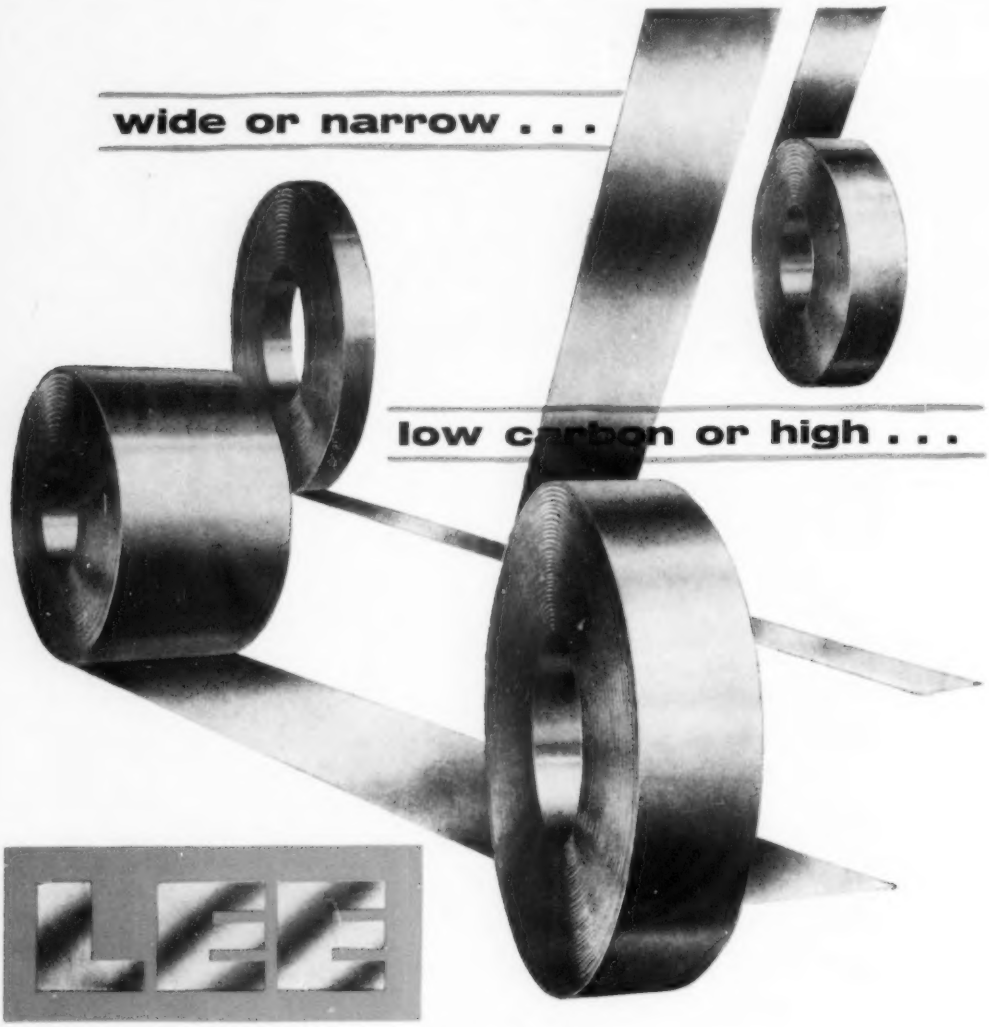

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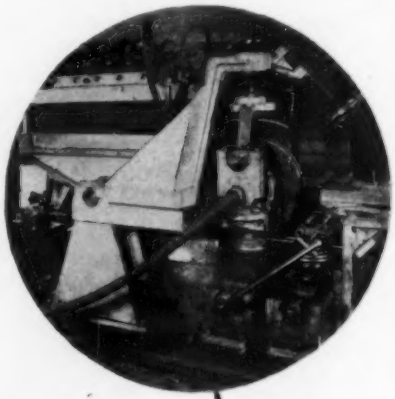
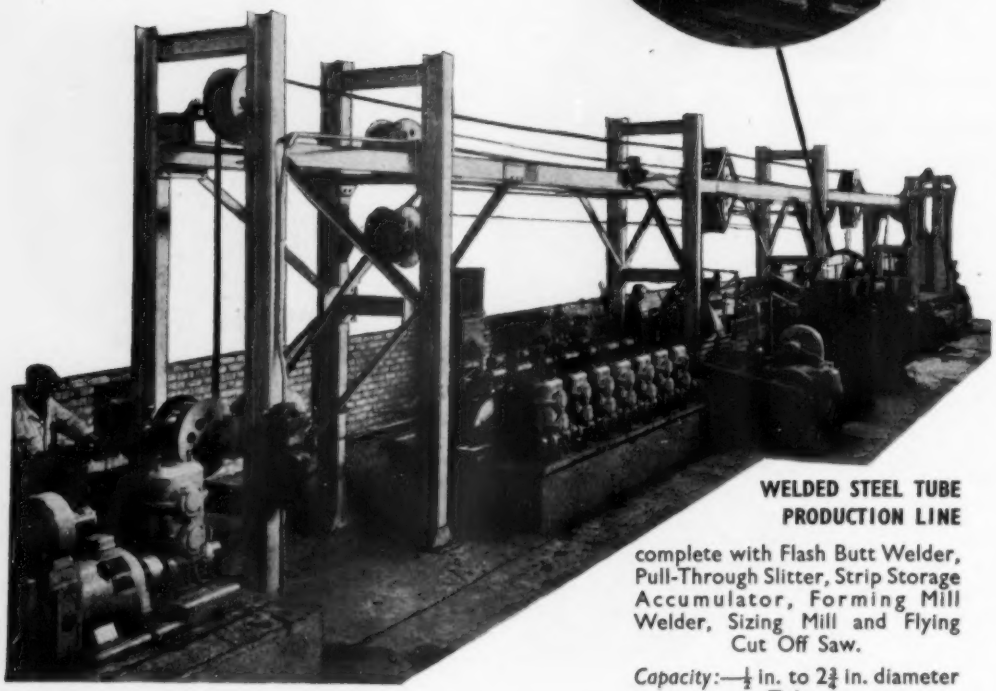
ARM

Close-up of Welding Unit





WELDED STEEL TUBE PRODUCTION LINE

complete with Flash Butt Welder, Pull-Through Slitter, Strip Storage Accumulator, Forming Mill Welder, Sizing Mill and Flying Cut Off Saw.

Capacity:—$\frac{1}{2}$ in. to $2\frac{3}{4}$ in. diameter Tube.

Speed:—40 to 120 feet per minute, with 50 cycle welding unit. 150 cycle welder supply can be supplied as an alternative.

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ROLLING MILLS and AUXILIARY EQUIPMENT
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STRIP, ROD and TUBE TRADES

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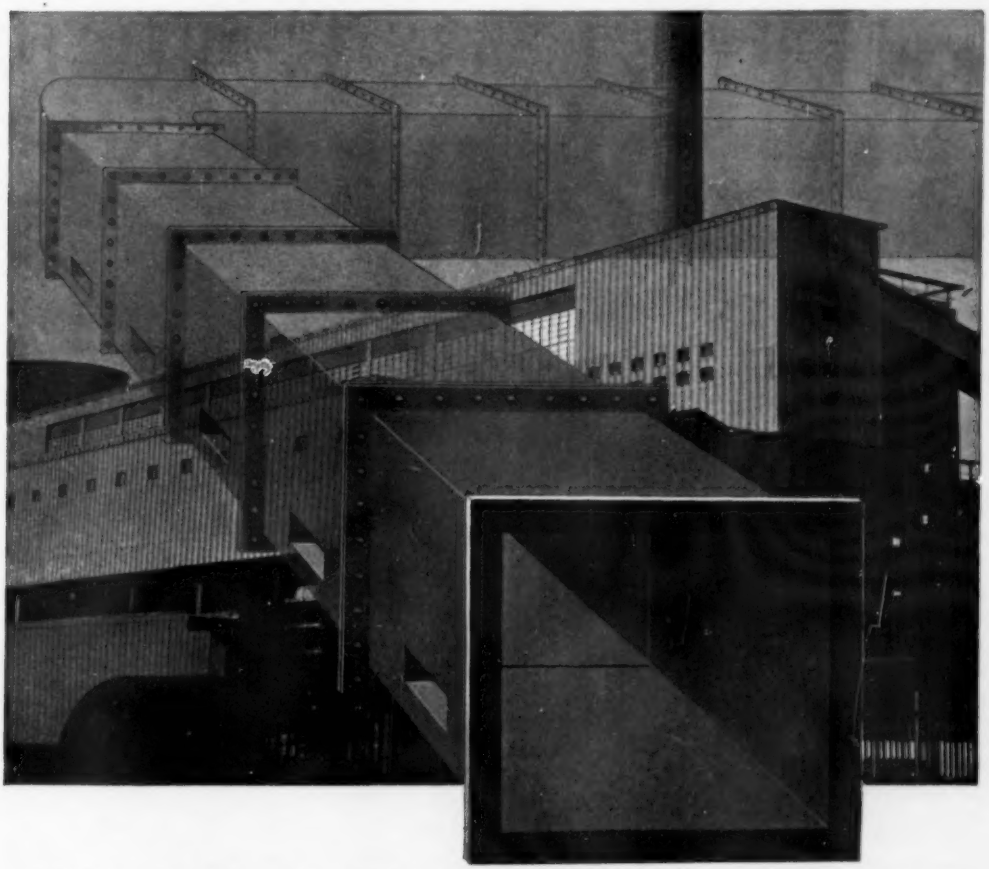

ANOTHER JOINTING PROBLEM SOLVED

In this factory it was essential that a solution be found to the problem of providing gas-tight, corrosion resistant seals and surface treatments for considerable lengths of metal ductwork.

Expandite RB200, a preformed Flexible Sealer, both waterproof and unaffected by dilute acids has proved to be ideal. Moreover, where airtight joints were required, RB200 grummets were used, thus providing a perfect seal.

On completion of sealing operation, Expandite METAGALV (an anti-rust process applied cold, by brush) was used as primer and, finally, a topcoating of EXPAFLEX added — a chlorinated rubber coating available in many colours, resistant to corrosive atmospheres and providing a pleasant surface finish.

Wherever sealing, jointing or corrosion problems occur, either 'on site' or at drawing board stage, builders, architects and civil engineers are recommended to consult the Expandite Technical Service Department for advice on these matters which is given without any obligation.

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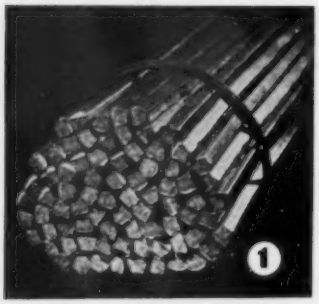
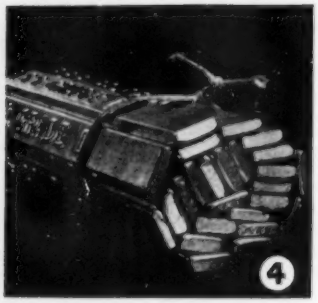
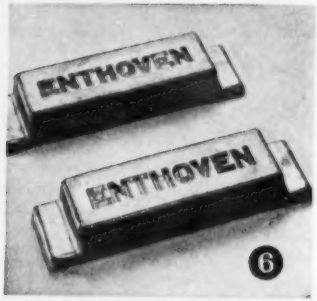


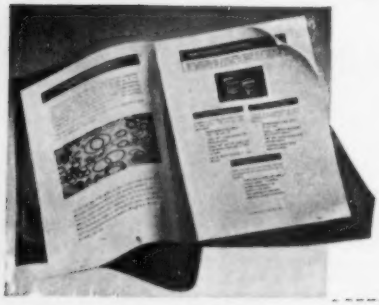
A few examples from a wide range of solders and solder products manufactured by Enthoven. If there's a soldering job to be done, there's an Enthoven product to do it — a product which stems from 150 years experience and 'know-how' in non-ferrous metals.



If you use solder you should contact Enthoven who will be pleased to assist you technically in addition to supplying the finest quality materials.

As a first step why not send for our booklet on ENTHOVEN SOLDER PRODUCTS.





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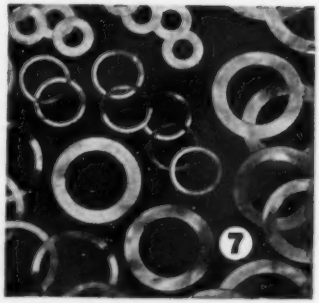

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Such close shearing tolerances can be maintained that for many fabrication purposes, Bronx sheared edges require no further preparation.

Illustration shows Bronx Heavy Duty Plate Shears, capacity 3' × 2" as supplied to Messrs. Appleby Frodingham Steel Company, Scunthorpe.

These heavy duty shears are supplied complete with hydraulic hold-down, and are made in all sizes.

★ *There are also Bronx Press Brakes, Plate Bending Rolls, Sheet and Plate Levelling Machines, Tube Straightening Machines, etc. Write for Catalogues.*

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Guillotine Shears

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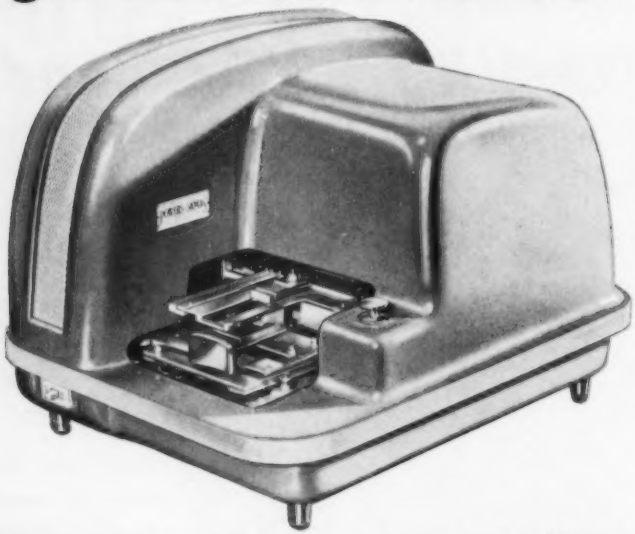
Design success for I.C.T



Cellobond Polyester/Glass

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Re-styled by Mark Schejbel, one of Britain's leading industrial designers, the I.C.T punched card reproducer has its cover and base moulded in Cellobond Polyester/Glass. Result : an outstanding design—a more efficient machine. The Cellobond mouldings used are lighter, stronger . . . they replace space-wasting angles with stress-resisting curvatures . . . and they cost two-thirds less than the metal components previously used.

Potential users please note

* BRP can put you in touch with specialists in Cellobond Polyester/Glass construction.
* On-the-spot assistance is available to all Cellobond users.
* The process is discussed in BRP Booklet No. 106. Please write for a copy.

Cellobond Polyester/Glass saves Time and Labour

The new design, made possible by Cellobond Polyester/Glass, simplifies assembly of the machine and cuts production costs. Adaptable and dependable, Cellobond Polyester/Glass frees designers from the limitations of conventional materials, enabling manufacturers to combine form and function elegantly, reliably and more profitably.

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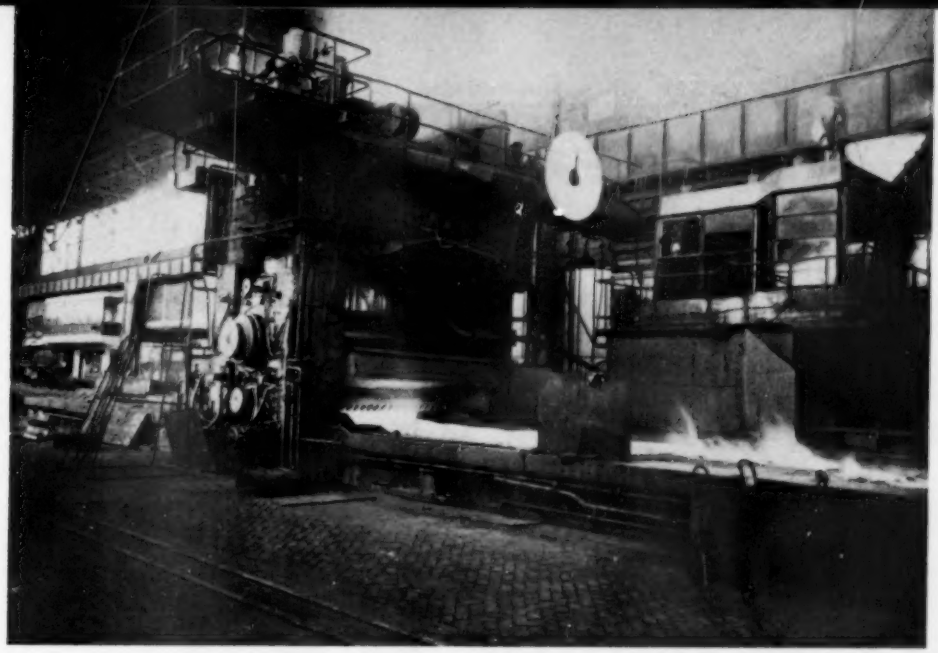

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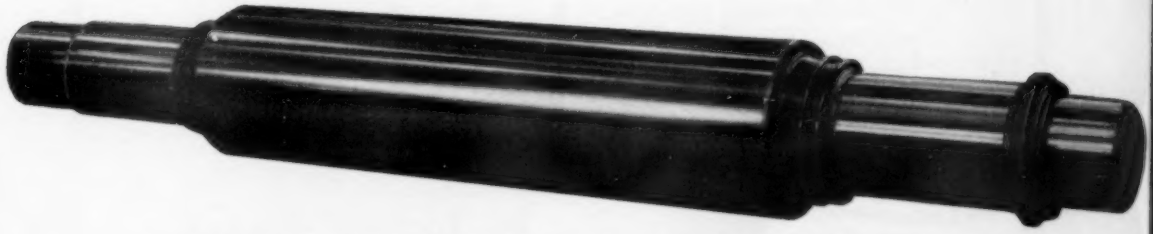
The U.X. Alloy Indefinite Chill Roll offers the maximum resistance to firecracking and spalling in the rolling of PLATES. U.X. has been outstandingly successful when used for work rolls in 4-High Reversing Plate Mills and also in the earlier stands of 4-High Continuous Hot Strip Mills. The alloys present ensure that the rolls wear with the minimum fall-off in surface hardness until the working life is completed.

The U.X. Alloy Roll is described fully in our brochure "ROLL MAKING," which shows this and many other types of roll manufactured by DAVY-UNITED.



DAVY-UNITED ROLLS

DAVY AND UNITED ROLL FOUNDRY LIMITED
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FOR METAL-ARC WELDING OF HIGH-NICKEL ALLOYS USE THE RIGHT ELECTRODE

For welding the high-nickel alloys special electrodes have been developed to give the best results. *Don't spoil good materials by using the wrong electrode.*

MATERIAL	METAL-ARC ELECTRODE	MATERIAL	METAL-ARC ELECTRODE
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MONEL® *corrosion-resisting alloy*	'I30' MONEL	NIMONIC® 75 NIMONIC® 80A NIMONIC® 90 *heat-resisting alloys*	NICREX® 4 or CHROMAC® N
'K' MONEL® *age-hardenable corrosion resisting alloy*	'134' K MONEL	BRIGHTRAY® B BRIGHTRAY® C BRIGHTRAY® F BRIGHTRAY® H BRIGHTRAY® S *high-temperature electrical resistance alloys*	NICREX® 3 NICREX® 4 or CHROMAC® M INCO-WELD® A NICREX® 4 or CHROMAC® N NICREX® 4 or CHROMAC® N
NI-O-NEL® *corrosion-resisting alloy.*	'135' NI-O-NEL		
CORRONEL® 210 CORRONEL® 220 *corrosion-resisting alloy*	CORRONEX® B		
INCONEL® *oxidation-resisting alloy*	'132' INCONEL		
INCOLOY® *heat-resisting alloy*	INCO-WELD 'A'		

® *Trade mark*

SEND FOR THIS BOOKLET

Full details of welding techniques by all processes are given in our welding handbook, '*Welding, Brazing and Soldering of Wiggin Nickel Alloys*'. Write for your copy.

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We have available a 16-mm sound film in colour entitled '*Welding of Wiggin High-Nickel Alloys*' which is available without charge for showing to engineering societies, training classes, etc.

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PGA M29

Draw benches
of standard and automatic types –
for single and multiple passes –
with hand-feeding of bars with milled tangs –
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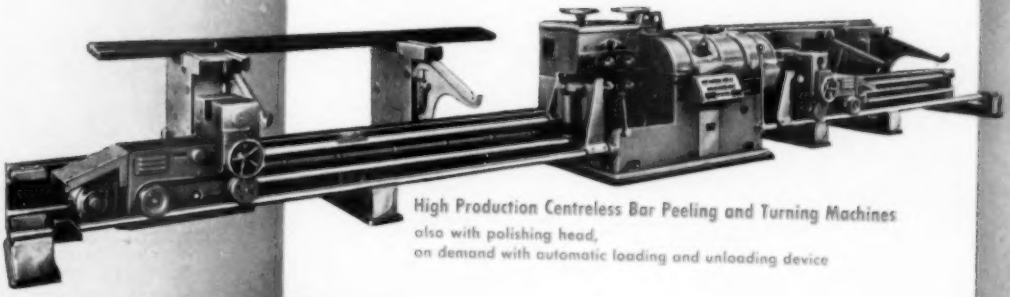
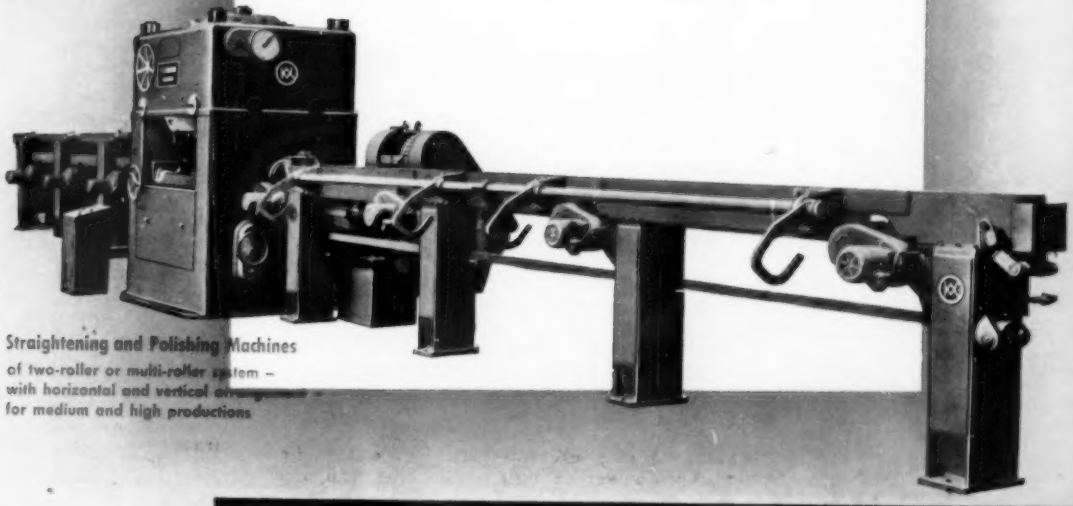
Machines and Plants for the cutting and non-cutting shaping of Bars.



High Production Centreless Bar Peeling and Turning Machines
also with polishing head,
on demand with automatic loading and unloading device



Straightening and Polishing Machines
of two-roller or multi-roller system –
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for medium and high productions

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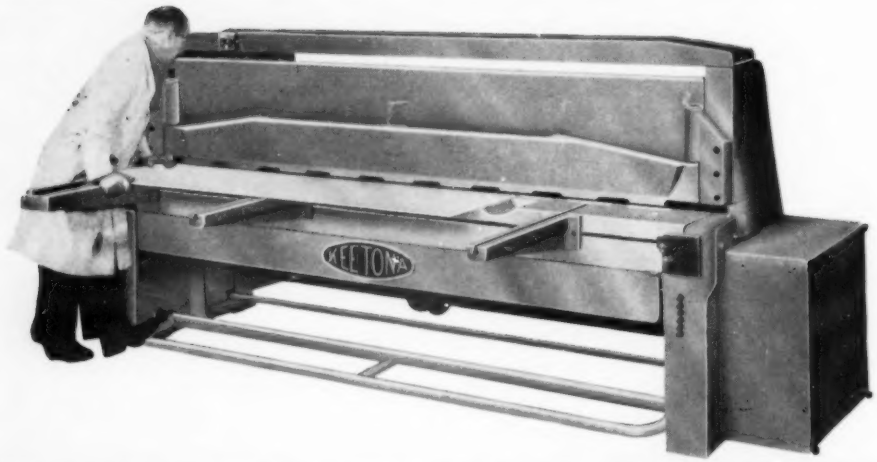
A new 8′ x $\frac{1}{8}$″ guillotine from Keetons



We have designed a new Guillotine Shear
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Modern plant installed in our new factory,
together with efficient production methods and good design, enable us to
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Exhaustive tests have proved its outstanding performance in reliability
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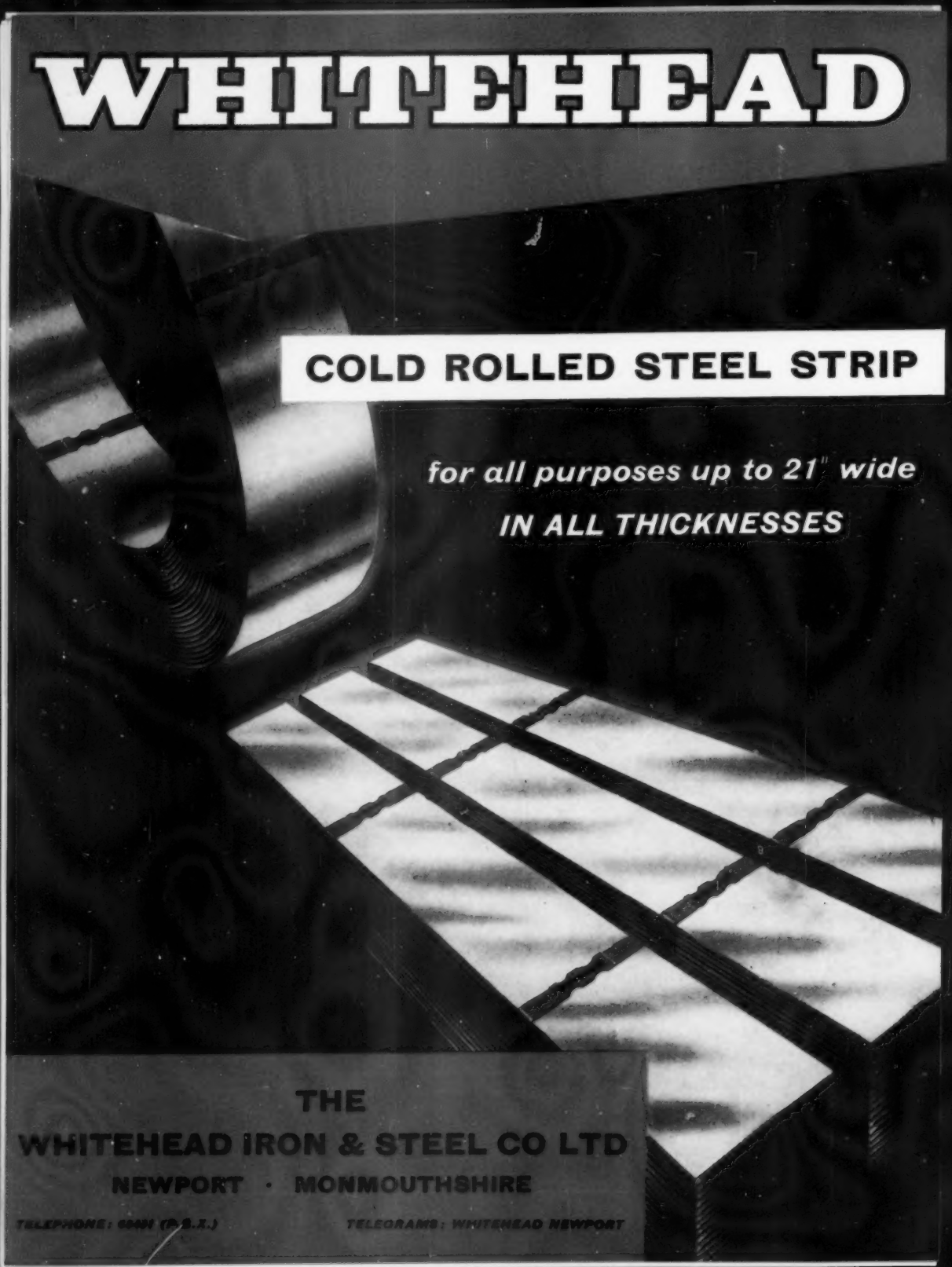

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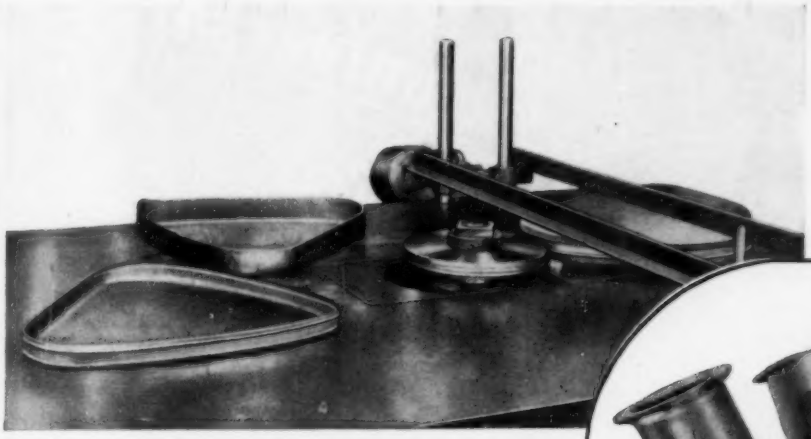

Illustrations show : (above) combined trim and bead, and (on the right) a necking-in operation.

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TRIMS — BEADS — FORMS

It handles almost any pressing in a single plane and is invaluable in any press shop.

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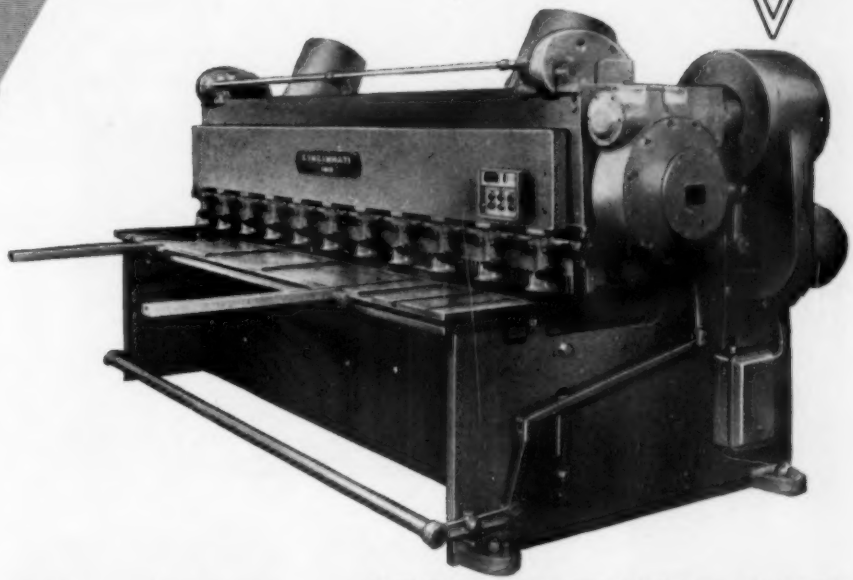

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. . . AND BRITISH MADE

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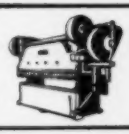

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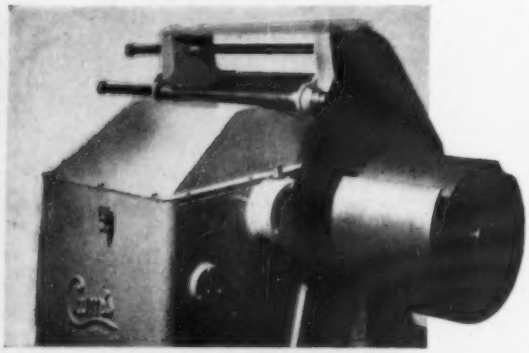

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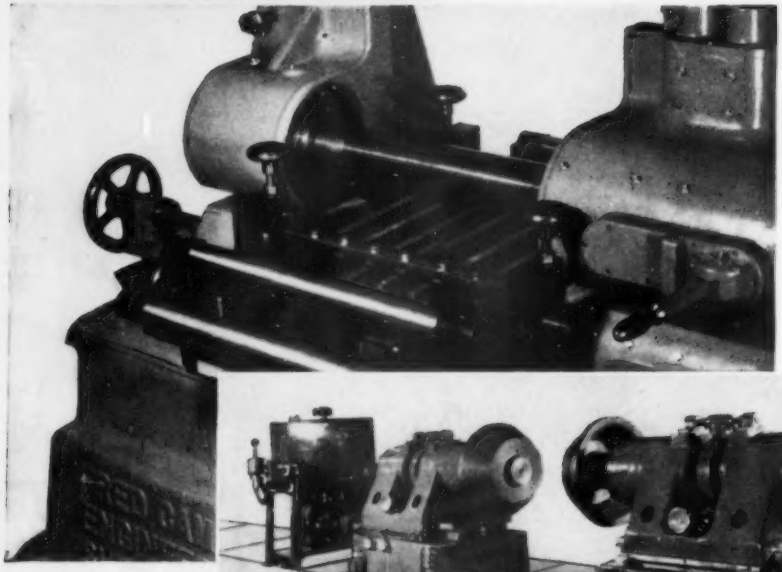

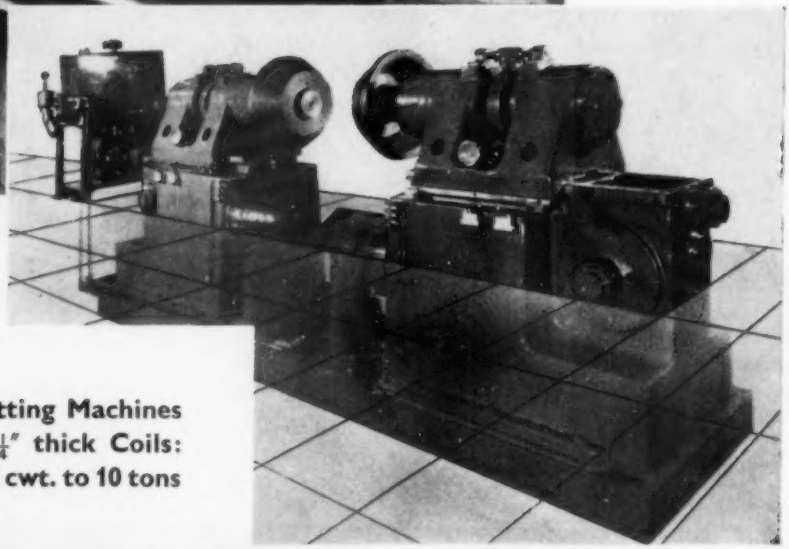

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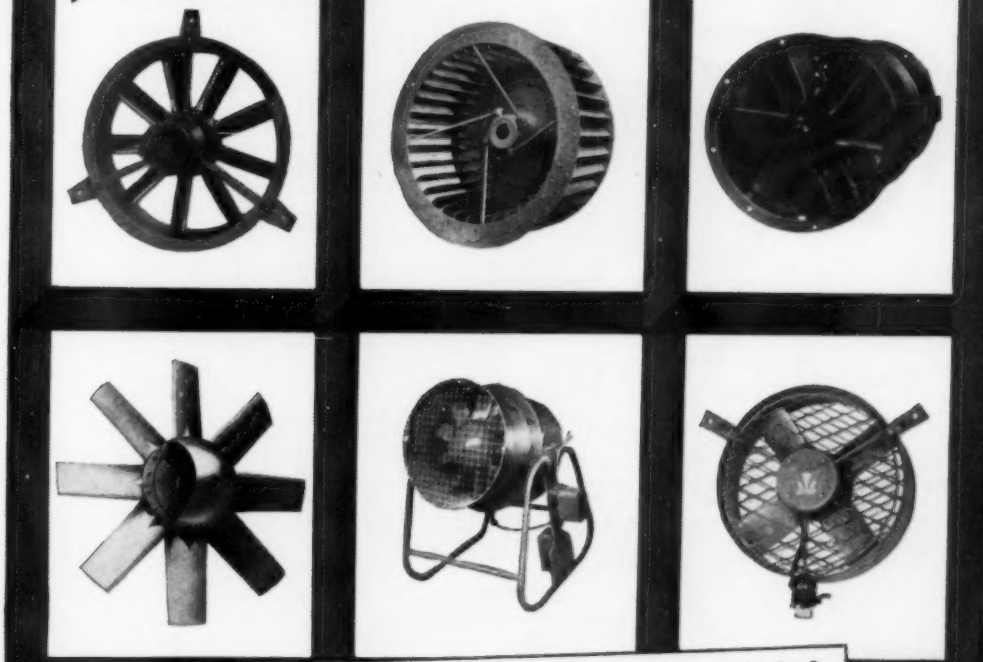

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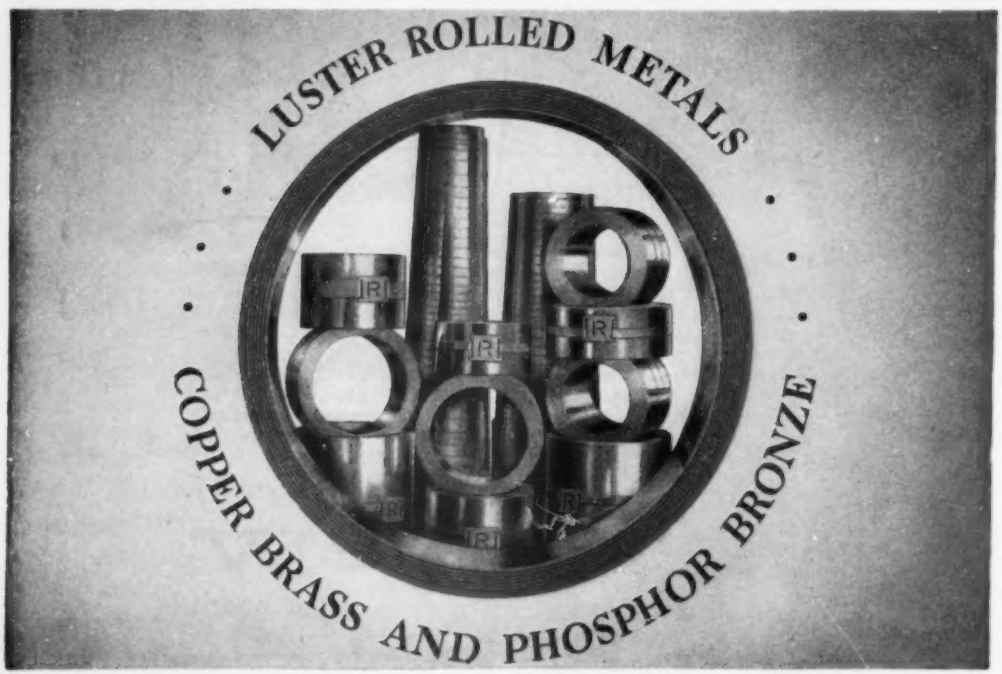

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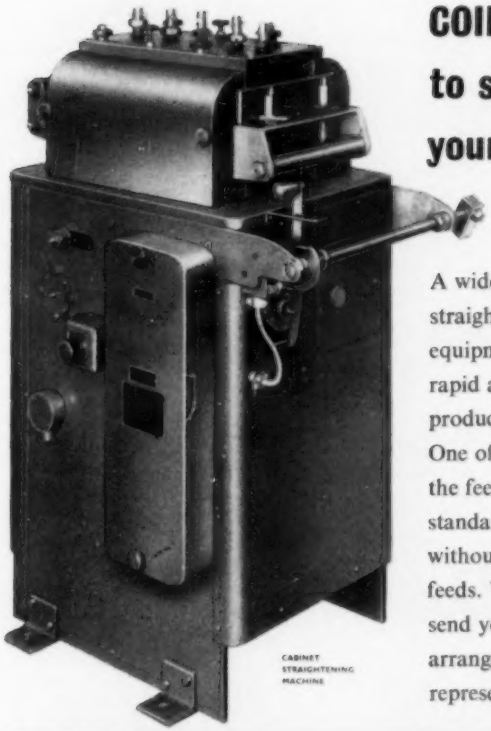

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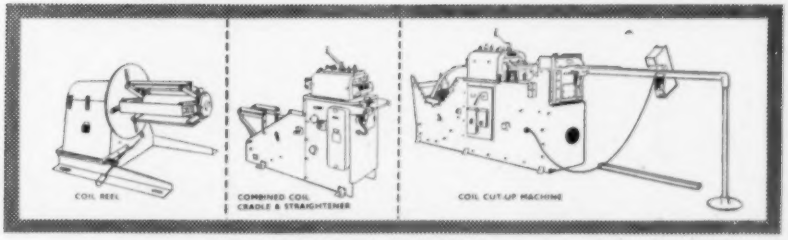

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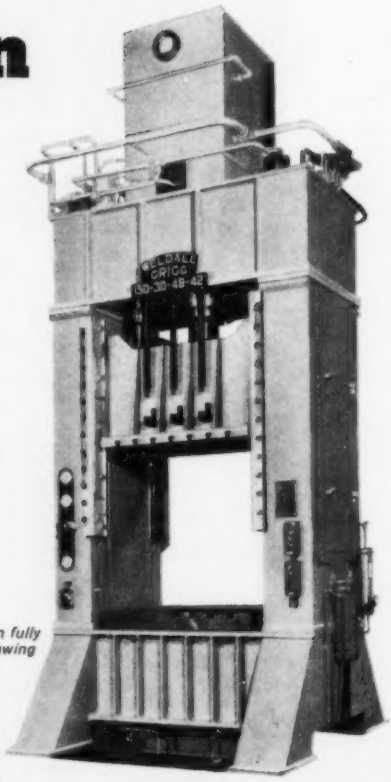

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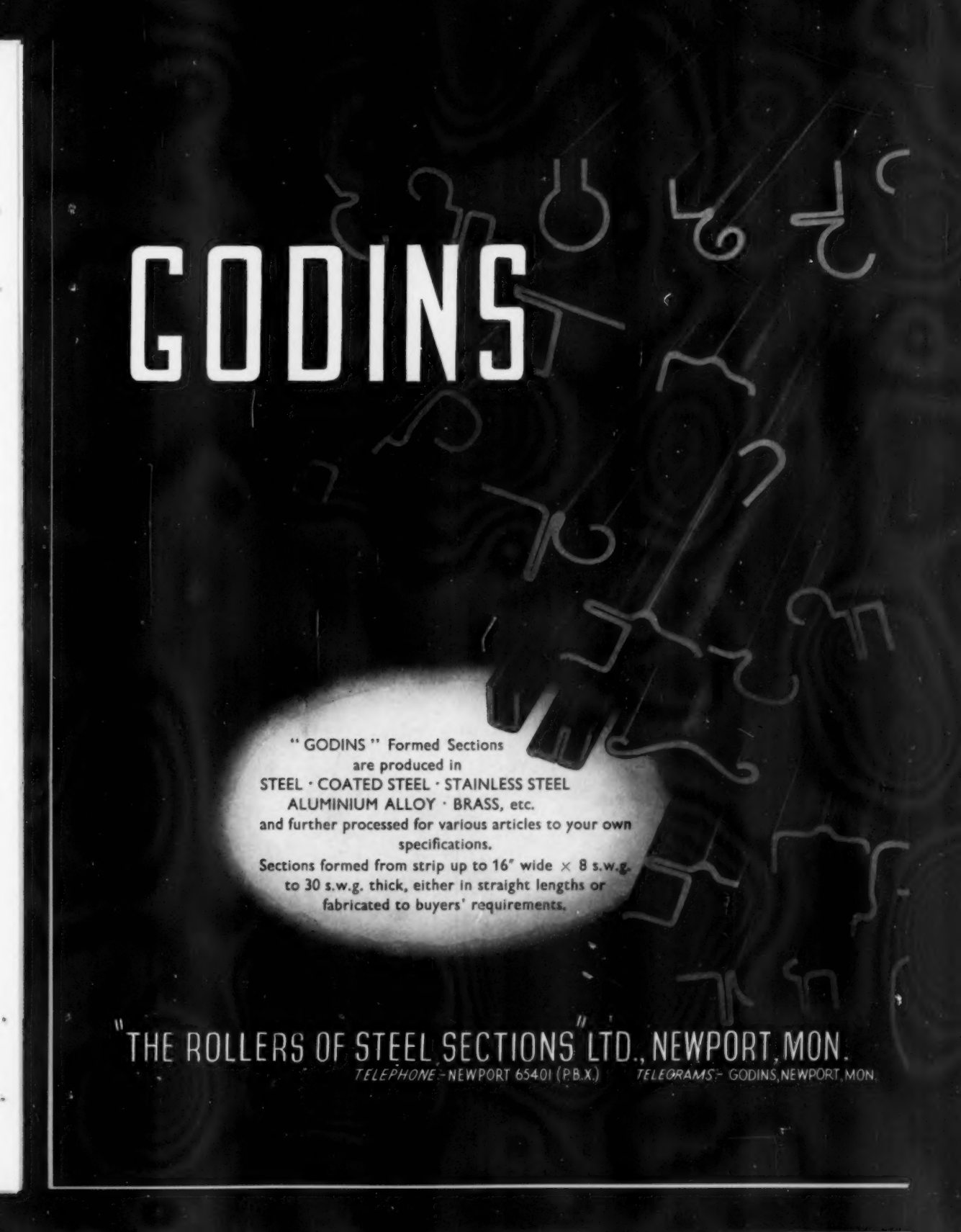

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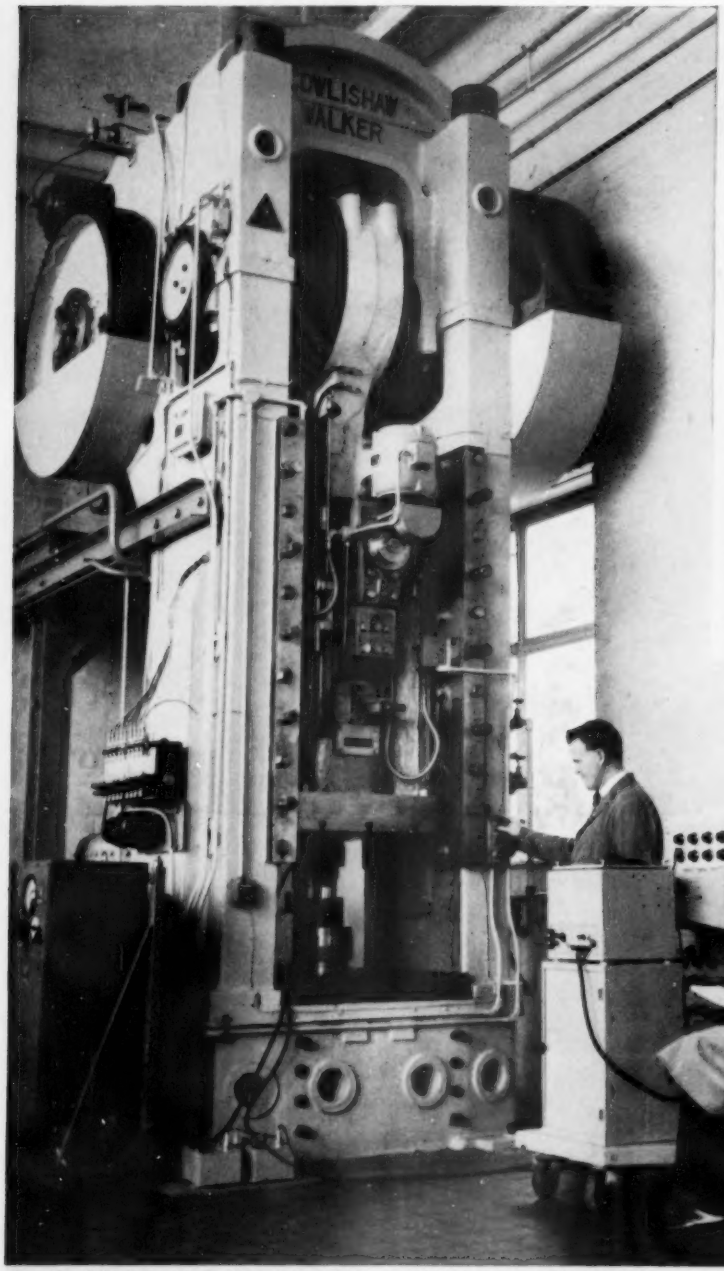

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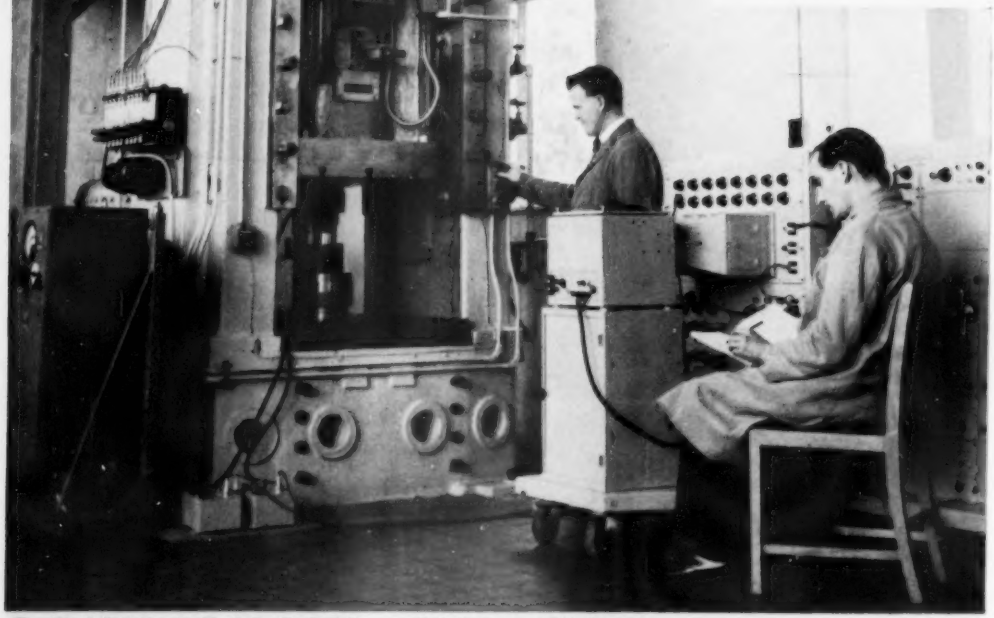

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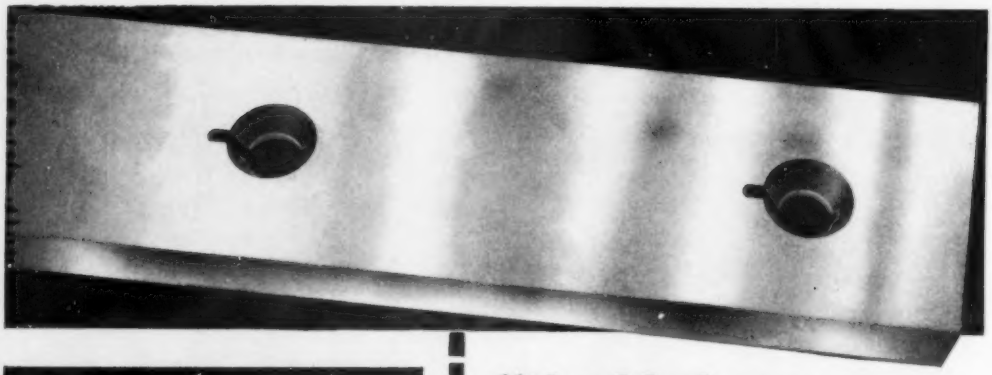

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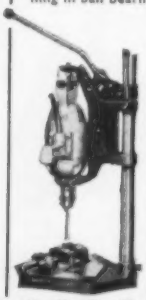

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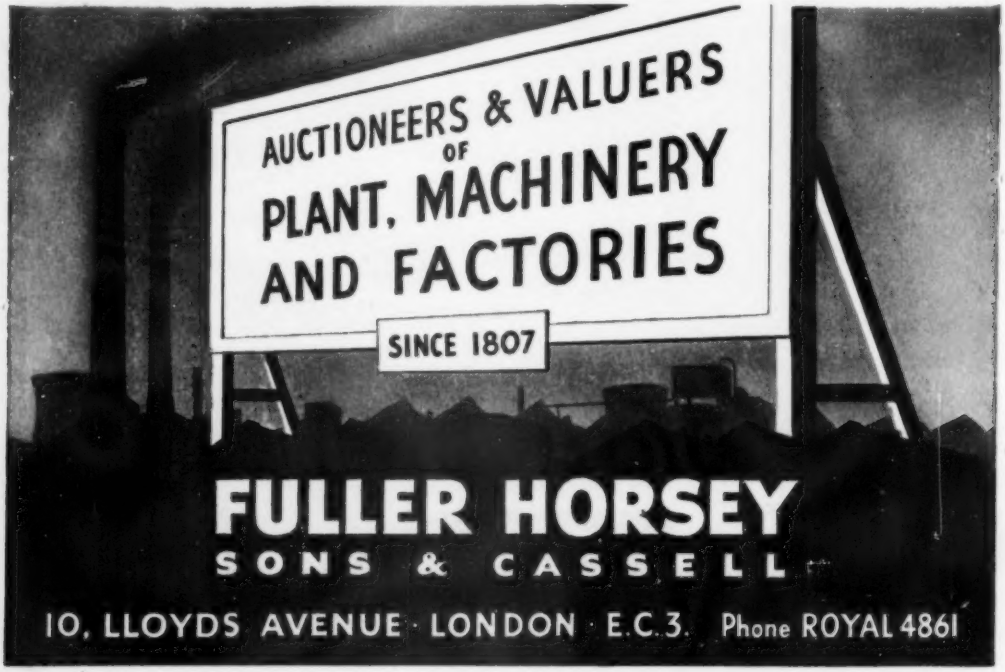

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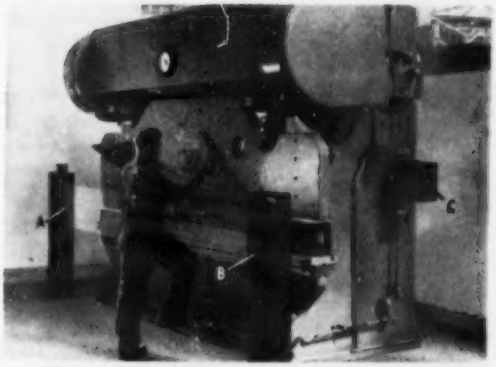

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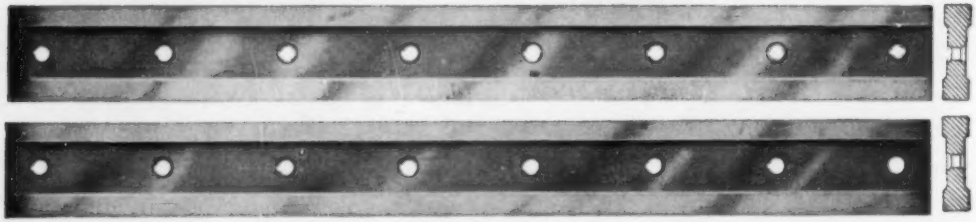

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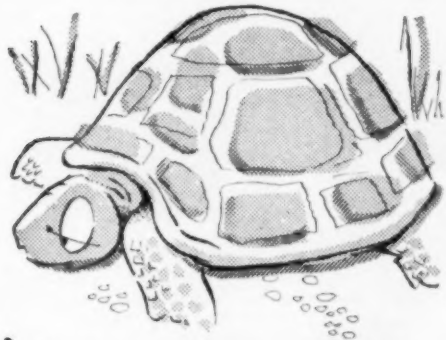

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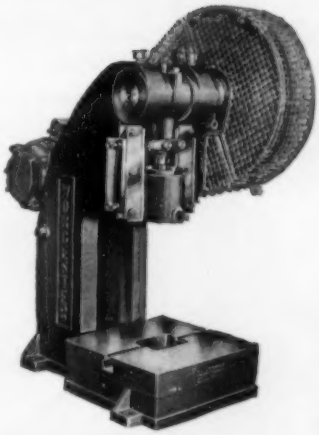

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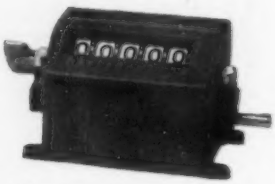

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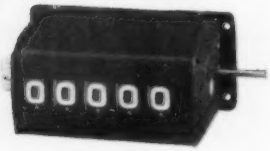

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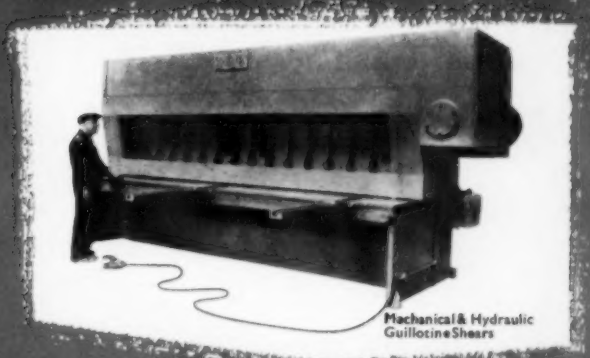
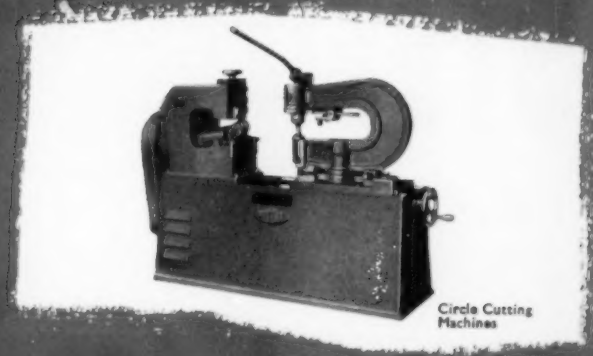


Mechanical & Hydraulic Guillotine Shears



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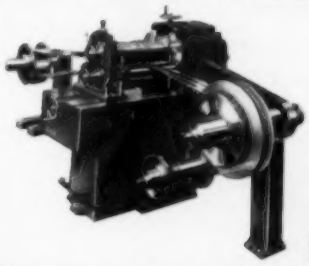

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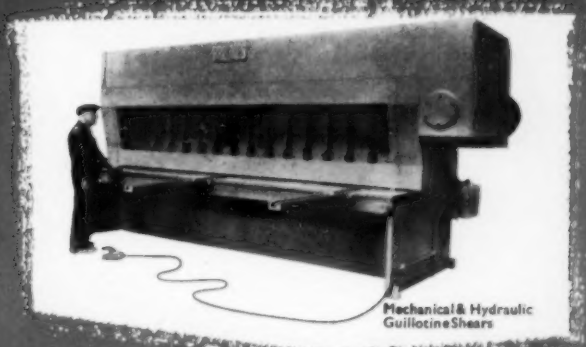

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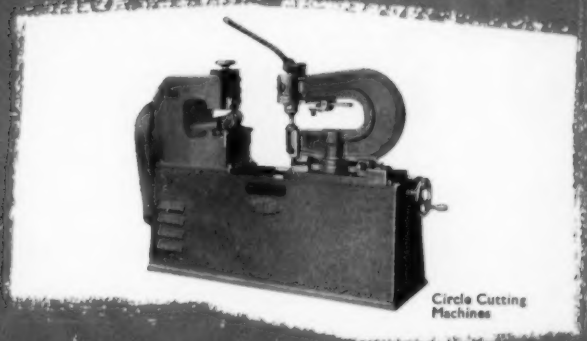

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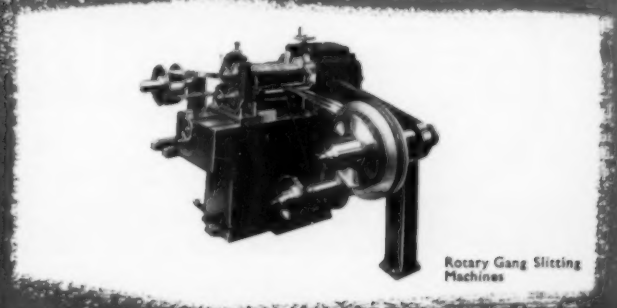

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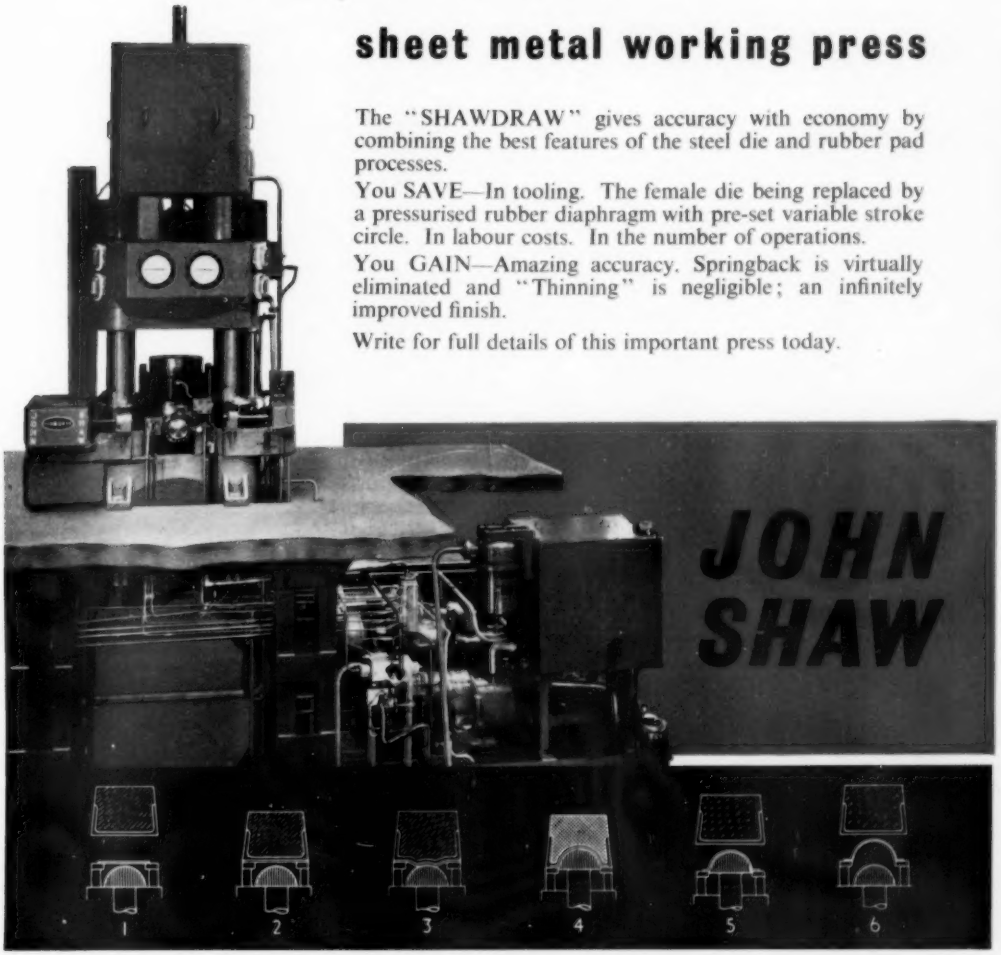
sheet metal working press



The "SHAWDRAW" gives accuracy with economy by combining the best features of the steel die and rubber pad processes.

You SAVE—In tooling. The female die being replaced by a pressurised rubber diaphragm with pre-set variable stroke circle. In labour costs. In the number of operations.

You GAIN—Amazing accuracy. Springback is virtually eliminated and "Thinning" is negligible; an infinitely improved finish.

Write for full details of this important press today.

The operating sequence of the "SHAWDRAW" is as follows:—

1. Blank is placed on tool nest above forming tool.
2. Flexible die member or diaphragm (which is situated in press head) is lowered and locked in position.
3. Pressure oil is pumped into flexible diaphragm to a predetermined setting.
4. Punch is moved upwards into flexible diaphragm, intensifying oil and thus forming shape over die.
5. Pressure is released from flexible diaphragm and head is raised.
6. Punch is stripped from finished part.

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Simple tools and attachments adapt the **PULLOMAX** *Plate and Sheet-metal Cutting Machine to a wide range of applications including :—*

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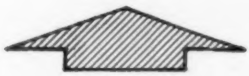

A typical joggling operation carried out on a Pullomax in 7 MINUTES.

Over-all Dia.	*$13\frac{3}{4}$"*
Joggle	*$\frac{1}{8}$" Deep*
Material	*16 s.w.g. mild steel*

The Pullomax Machine has effected considerable savings in the production of a variety of components. The above illustration is a typical example. Operations can be carried out on mild or stainless steel, brass, copper, aluminium, magnesium, wire mesh, fibre board and certain plastics. Made in 5 sizes up to a maximum edge-cutting capacity of $\frac{11}{32}$" in mild steel plate.

Pullomax P. 7 fitted with power feed device

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Orcene

manufacture a very wide range of drawing lubricants for specific metal treatments. Each is highly efficient in preventing friction between work and die and in avoiding "build-up" associated with the usual type paste/oil lubricants.

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becomes a less costly process with Orcene compounds. Die life is prolonged and rejected work is reduced to an absolute minimum. Orcene compounds do not stain, burning off readily in annealing processes and are easily degreased by Orpi alkali degreasers and emulsion cleaners.

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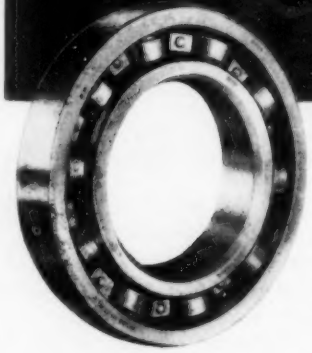

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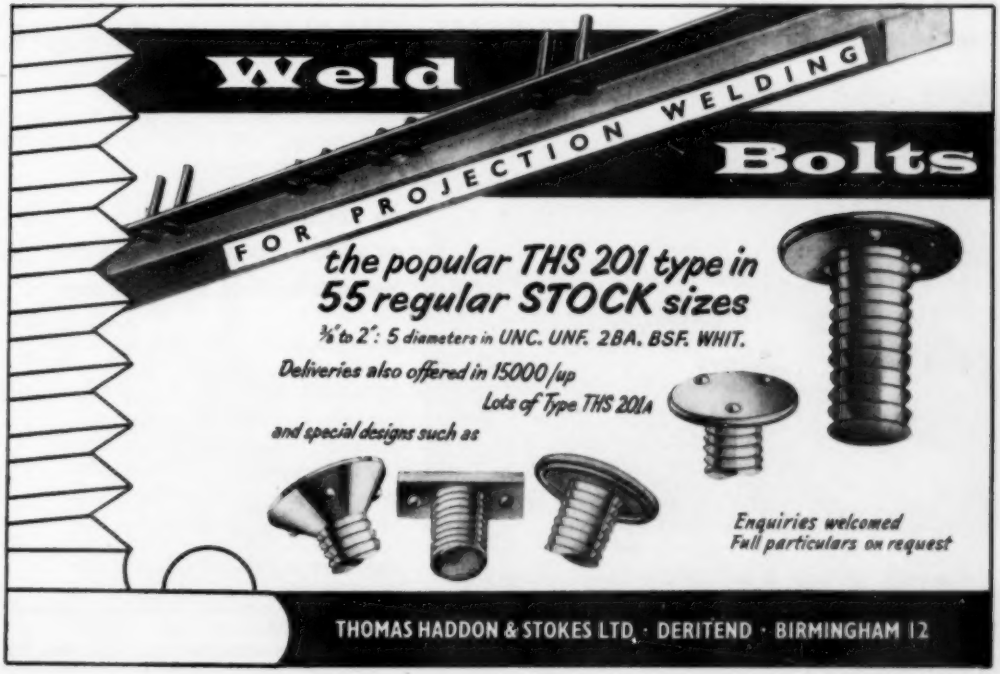
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All types of press work
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The "Imex" Rivet is now available in a limited range of sizes, including $\frac{1}{8}$ in., $\frac{5}{32}$ and $\frac{3}{16}$ in. dia. It can be supplied on two alternative mandrels which only break after the rivet is fully set. The short break mandrel fractures immediately under the head, which is thus retained within the set rivet. The long break mandrel fractures outside the rivet and its protruding part can be subsequently trimmed to give an entirely flush finish and a solid steel core to the rivet.

Write us now for more detailed information.

The trade mark "IMEX" is registered in respect of rivets in the United Kingdom and many other countries in the name of the Geo. Tucker Eyelet Co. Ltd.

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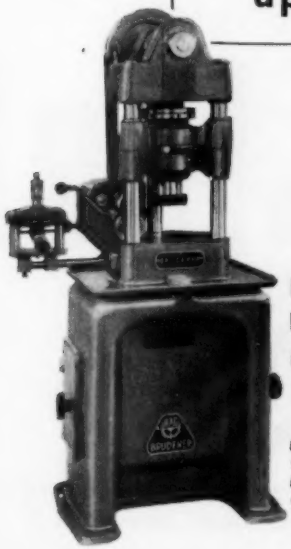
SWISS MADE high Precision automatic punching presses

up to 84,000 pressings hourly



- ★ Available in capacities of 12 and 20 tons
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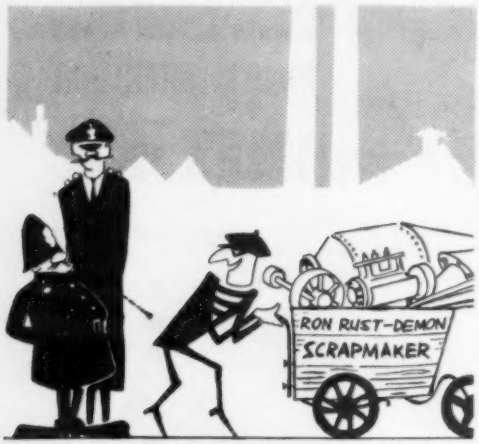

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YES, and it happens every day, probably in *your* production department.
Trouble is: you don't miss anything or you don't notice it, until *after* the damage is done. Your only course then may be to scrap your production in favour of a new lot which *must* be protected from rust quickly if the "rust thief" is not to rob you of another batch of brand new metal components.
Rust can, and does, play the "very devil" with most types of ferrous components during storage, for either long or short periods. Prevent this trouble by applying RUST VETO to your metal components immediately they leave your production department. The effectiveness of RUST VETO has been proved by users over many years. Different grades are available from grease to very fluid consistency. Also hard-drying types as well as special water-dispersing grades and finger-print neutralisers.

Recommendation and sample gladly submitted.

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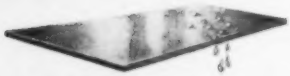
Special water-displacing grades actually raise water off metal to form a long-lasting protective film ***under the moisture.***



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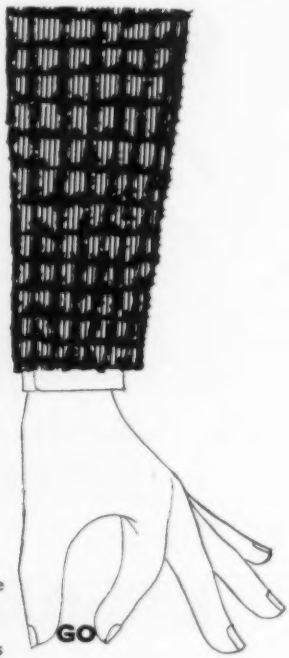

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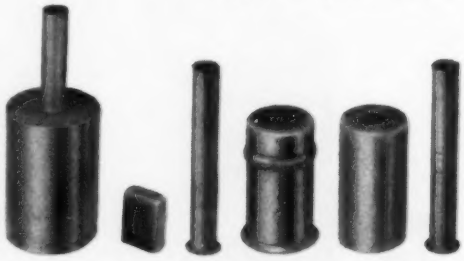
and we'll design and produce to your requirements



We invite your enquiries

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PRESS SHOP AUTOMATION

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You can depend on Udal.

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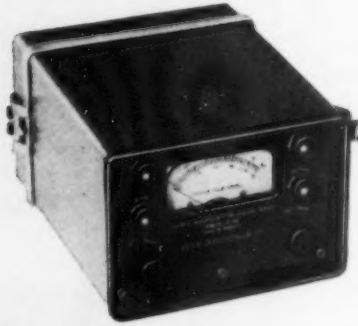
M563 Gamma Backscatter Gauge

the safe, reliable, cost-saving way!

Accurate detection and measurement of corrosion can be a hazardous and costly problem. For this work we have designed a completely self-contained, light-weight, portable Gamma Backscatter Gauge, utilizing transistors and printed circuits.

It is designed to measure the thickness of pipe-walls or sheet materials when access is possible to one side only. It will also operate through a thin paint film so that it is unnecessary to remove this—no special surface preparation is required.



EKCO nucleonic gauges

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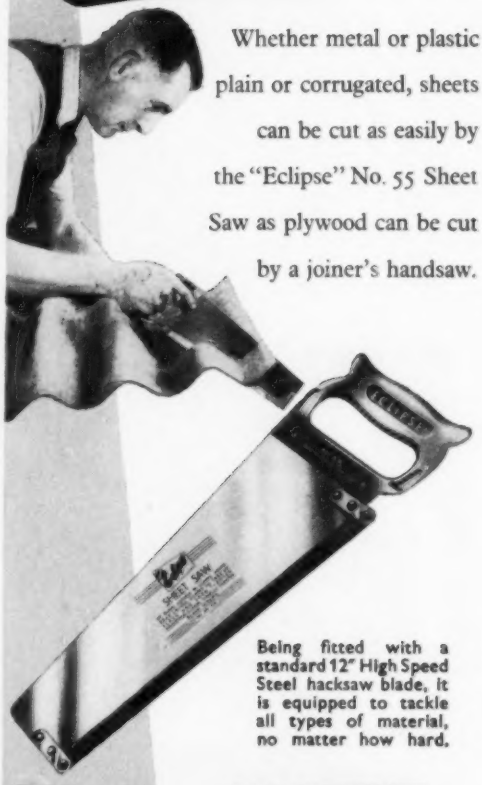
WPS-293

NOW it's easy to cut all sheet materials



Whether metal or plastic plain or corrugated, sheets can be cut as easily by the "Eclipse" No. 55 Sheet Saw as plywood can be cut by a joiner's handsaw.

Being fitted with a standard 12" High Speed Steel hacksaw blade, it is equipped to tackle all types of material, no matter how hard.

Eclipse **SHEET SAW**

Made by James Neill & Co. (Sheffield) Ltd., and obtainable from all tool distributors

SM 4

Of these three typical Lancastrian Presses, that shown at bottom right is a Lancastrian 150-ton triple-action Drawing Press. This press exerts 150 tons pressure on the downstroke of the main slide, 128 tons on the downstroke of the blank holder and 42 tons on the upstroke of the die cushion. The maximum daylight between bolster plate and blank holder is 48 in.; maximum diameter of draw is 28 in. and maximum depth of draw is 12 in.; overall height 17 ft. 5 in.; width 7 ft. 9 in.; width across platform 10 ft. and depth 4 ft. 1 in.

The illustration top left shows a 1,200-ton triple-action deep Drawing Press and top right a 300-ton double-action Press. These are more fully described in other advertisements.

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Foster Yates & Thom Ltd.

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London Office: Terminal House, Grosvenor Gardens, S.W.1. Telephone: Sloane 2255

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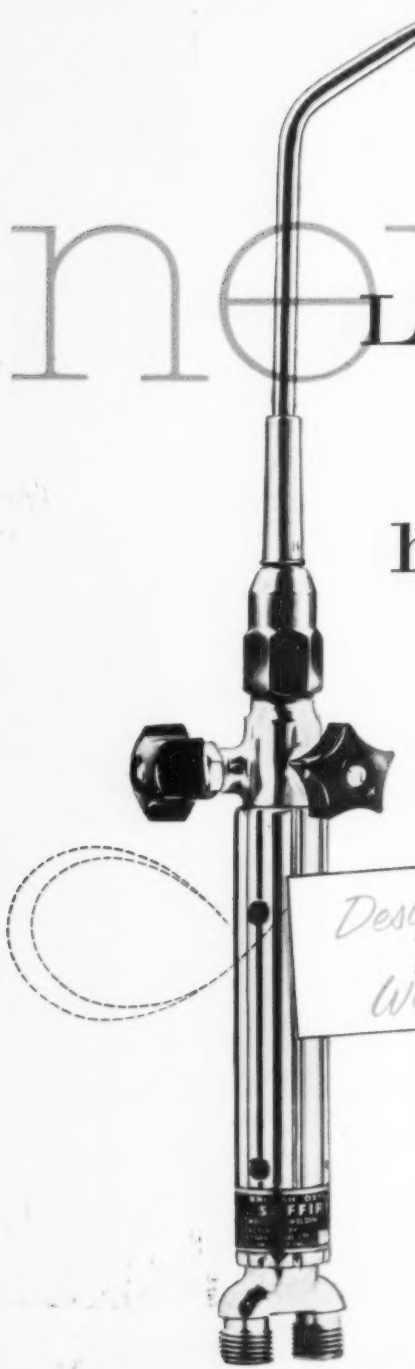

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- ✳ *Beautifully balanced*
- ✳ *Designed by experts*
- ✳ *Precision made*
- ✳ *Greater flame stability*
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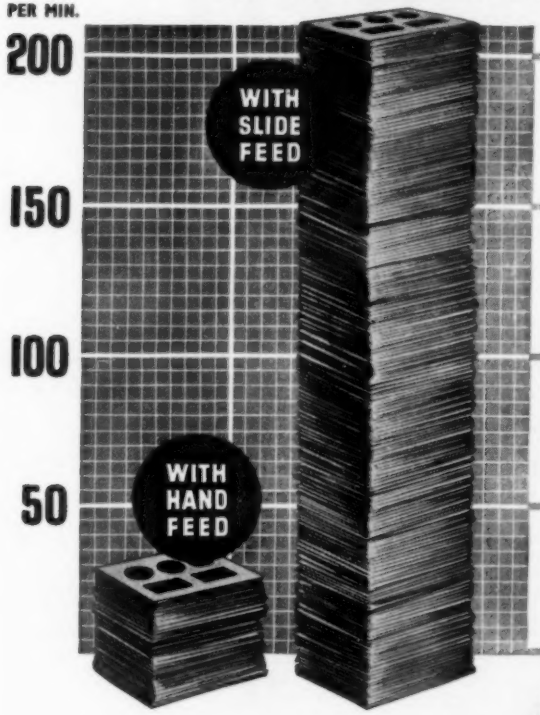
5 TIMES as many STAMPINGS
- AT A *FRACTION* OF THE *COST!*



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one operator to several presses

FULLY MECHANISES YOUR PRESS

EASY SETTING
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Our Feeds are built and designed for pitch accuracy and long life. Can be mounted to almost any type press. Suitable drive parts are supplied. Feeds available in nine sizes, up to 20" wide. Stroke and width infinitely variable. Makes a press fully automatic.

★ *Please send us details of your problems. Our Engineers will deal with them immediately.*

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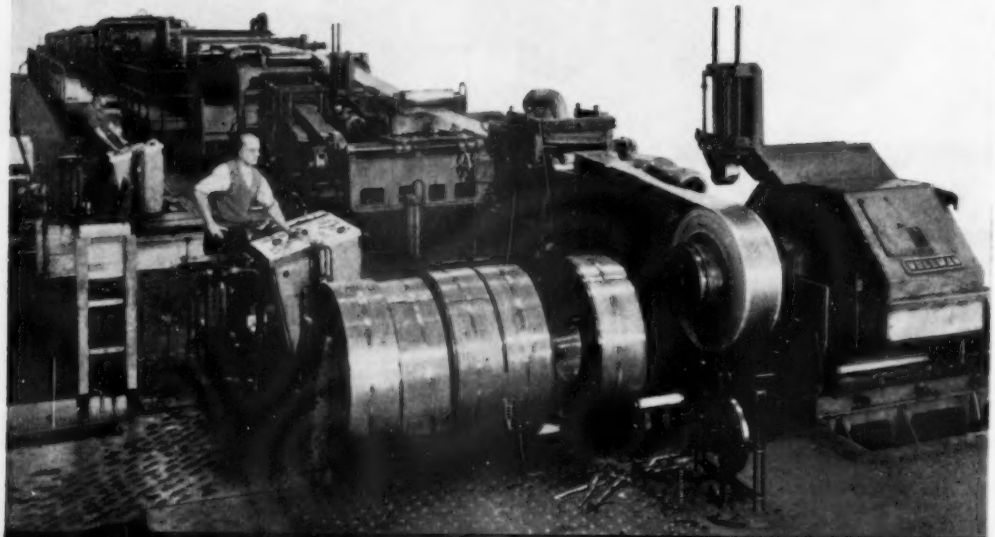
Rolling Mill Equipment

Below is illustrated the exit end of a Wellman Multi-Strand Continuous Pickle Line, for processing low carbon and mild steel hot rolled strip, installed at the Works of a large Sheffield manufacturer. The line is at present operating with two strands, but will ultimately be arranged for four-strand simultaneous processing.

This is one of the numerous Wellman installations in both the United Kingdom and Overseas, designed for the continuous processing of low carbon, mild, silicon and stainless steels in a wide variety of gauges and widths.



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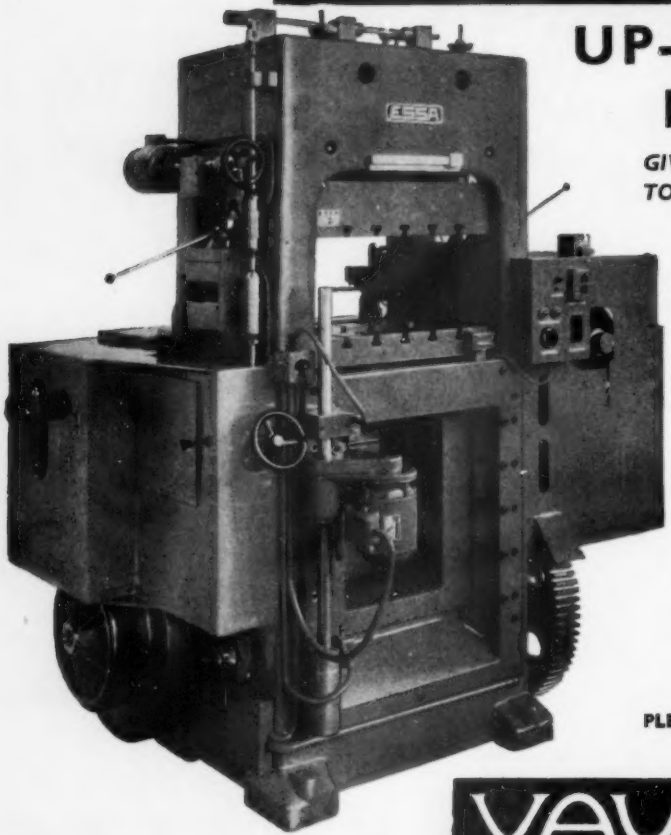

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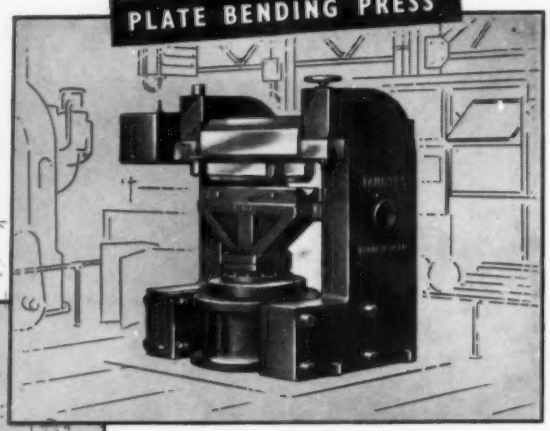

Tangye Plate Bending presses are in many sizes and capacities but a popular feature is shown above. The balanced head swings horizontally to enable the withdrawal of work of the box variety. Presses for work up to 4 ft. wide are usually powered by a single ram. Additional rams are incorporated in accordance with size and power required.

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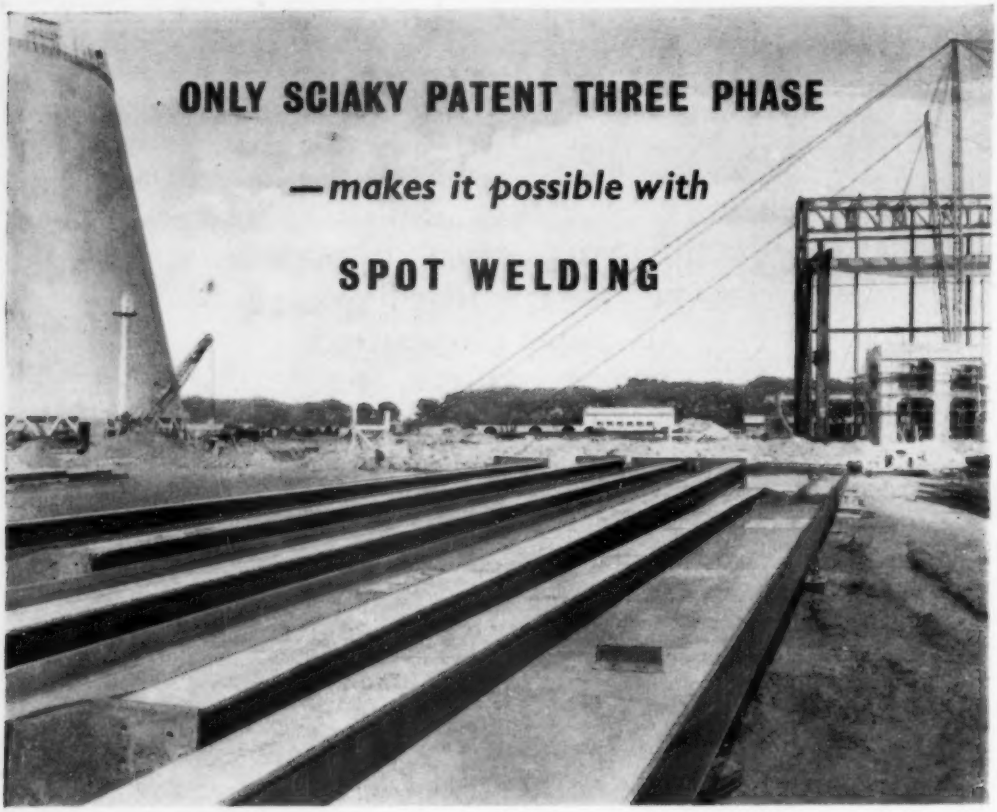

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The steel beams, as much as 1½" + 1½" thickness in places, shown in the illustration above are prefabricated by spot welding on Sciaky Patent Three-Phase Resistance Welding machines. This power station which is now under construction is fabricated entirely with Resistance Welded steel girders which require no special preparation and enable the building to be erected at a third of the labour costs required by conventional methods. Look at the size of those spots! . . . How's that for Sciaky "Three-Phase" reliability?

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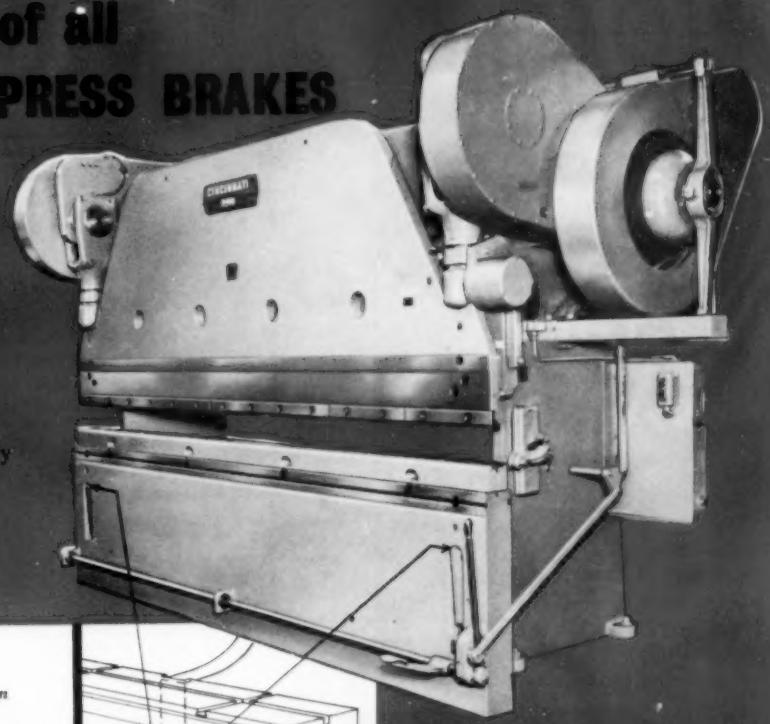

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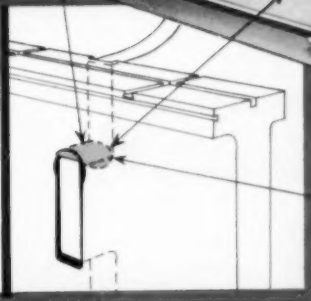

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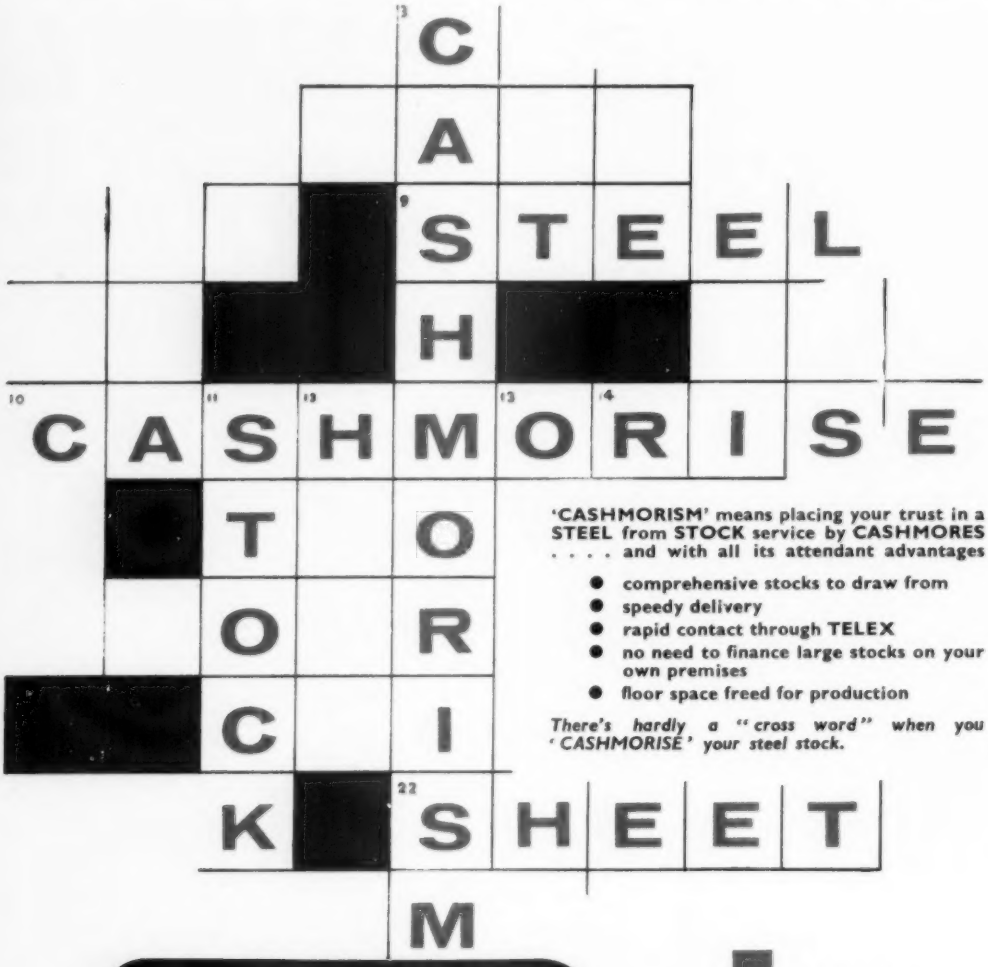

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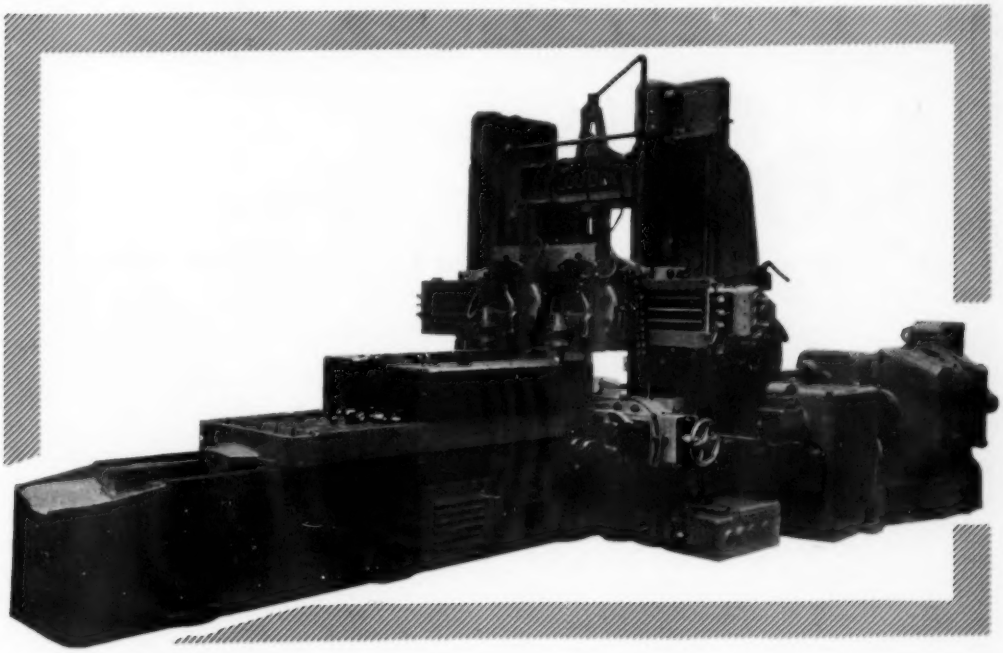

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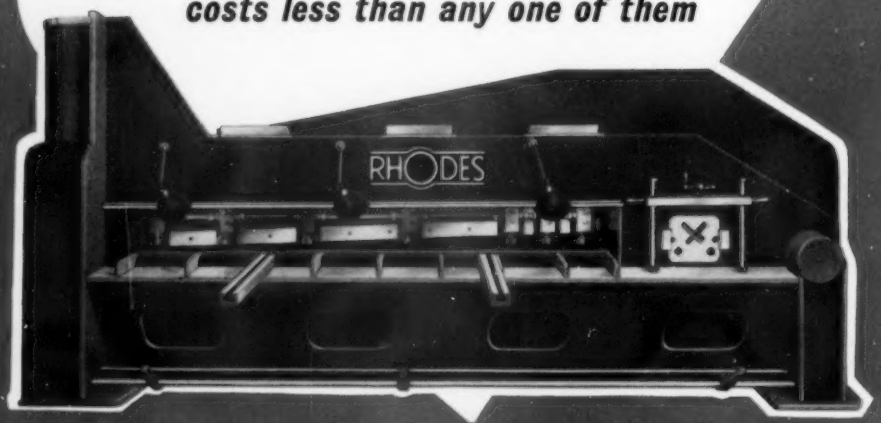

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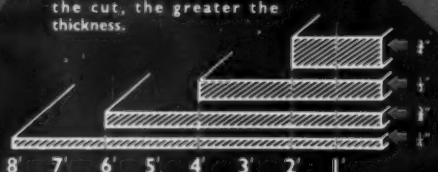

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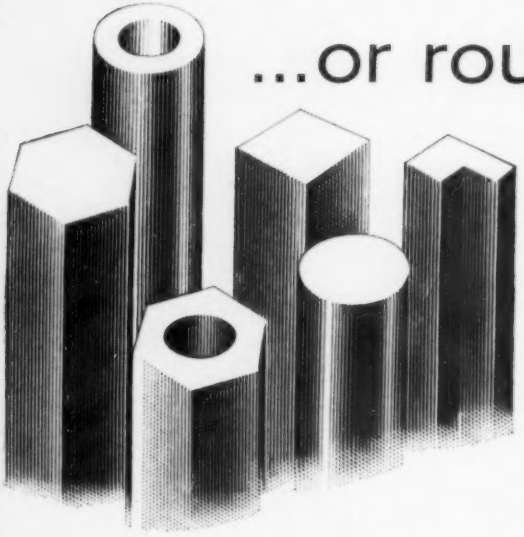

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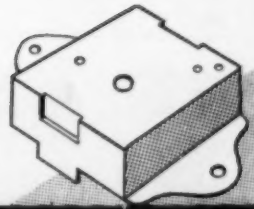

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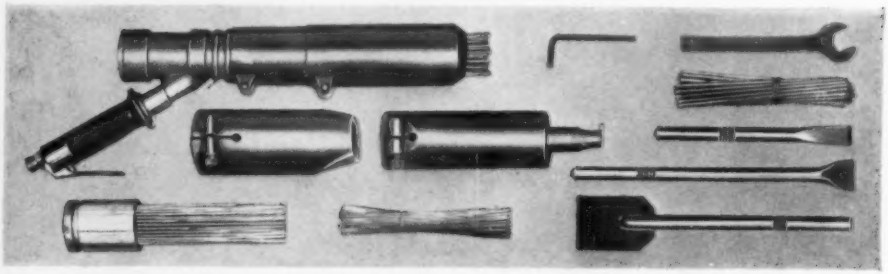

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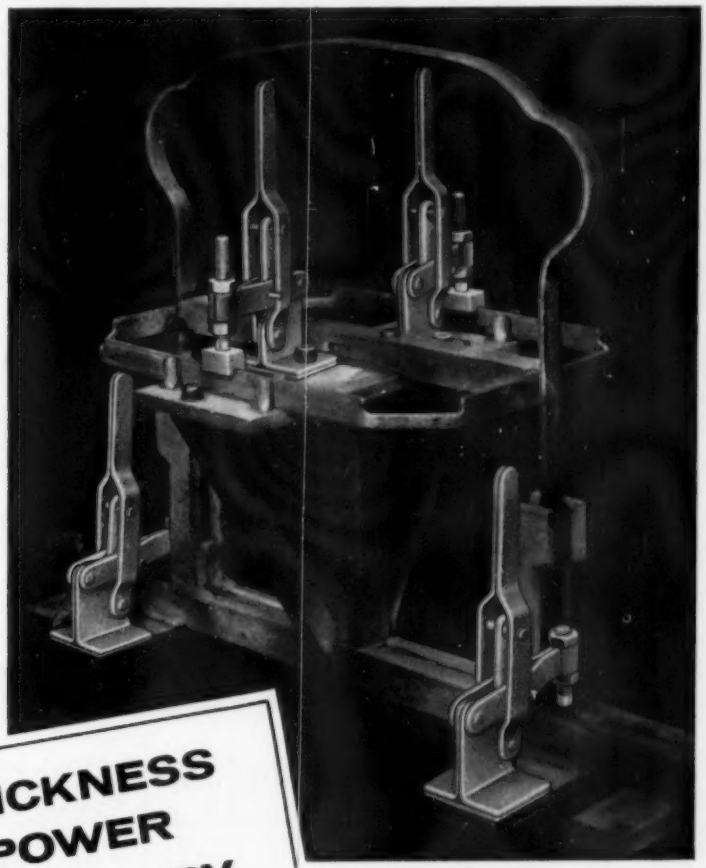

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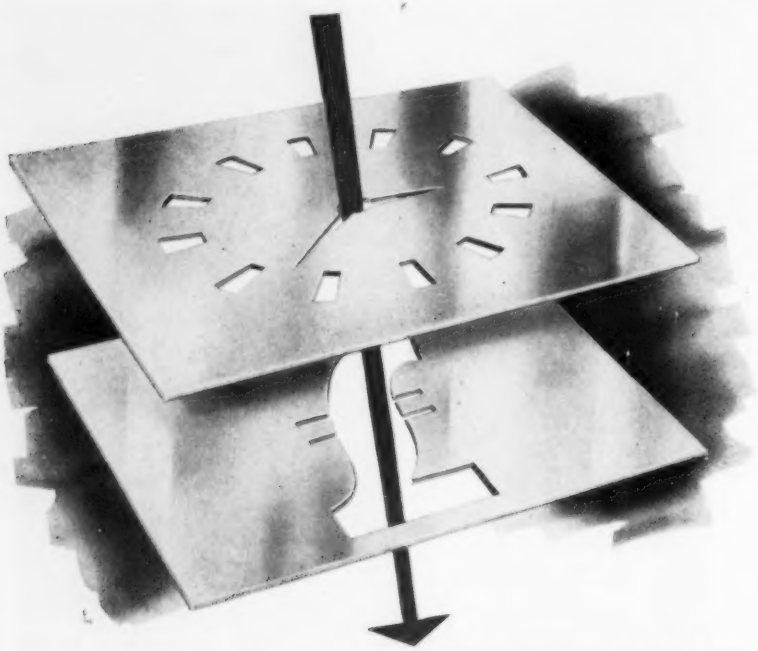

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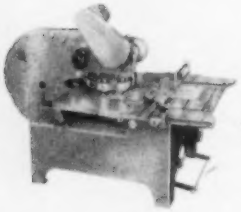

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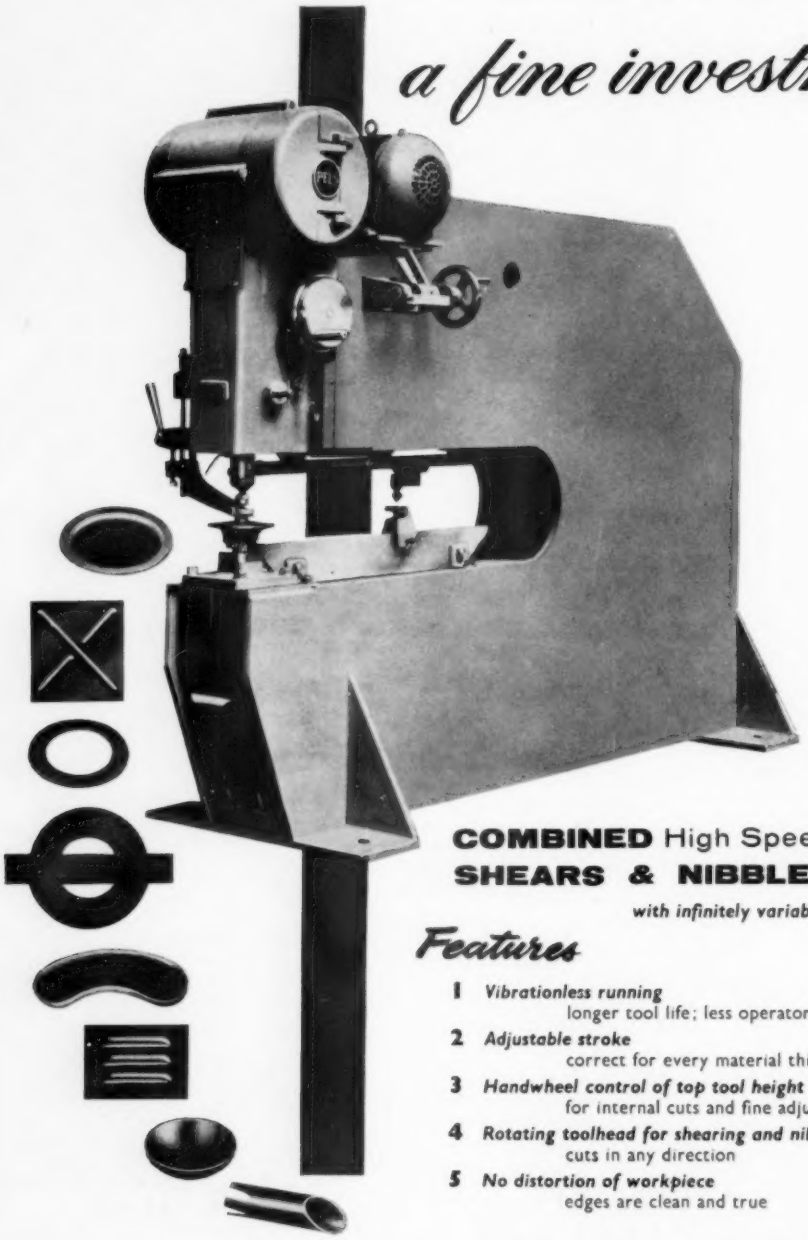

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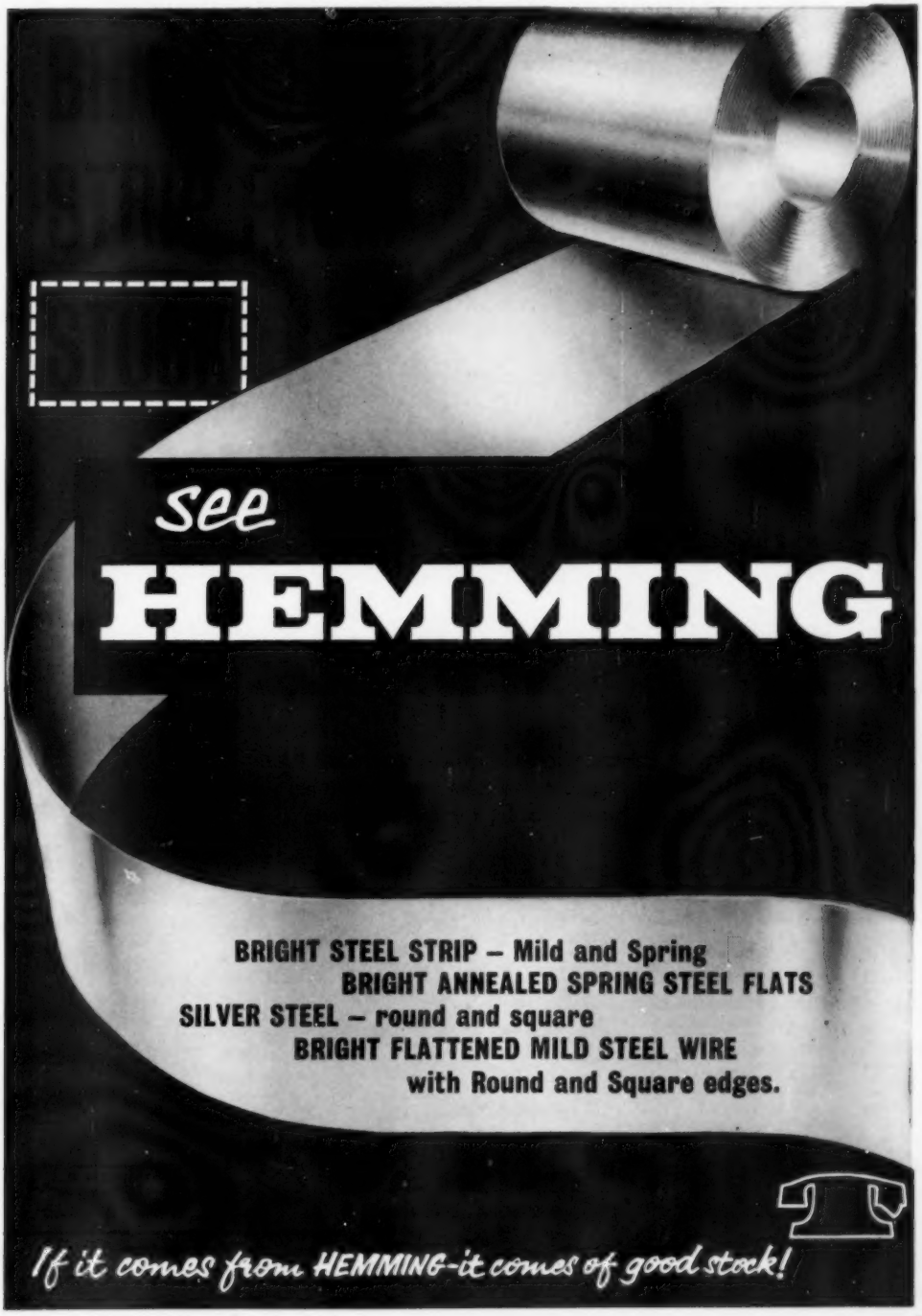
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Firth Cleveland now specialize in high-carbon steel strip to the exclusion of all other cold-rolled products. This description gives full details of the works layout, the continuous pickle line, cold rolling, roll grinding, annealing, strip hardening and tempering, finishing operations, and testing and inspection.

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This is the second report of the Testing and Measurement Sub-Committee (chairman Mr. J. F. Kayser) of the Institute of Sheet Metal Engineering. The report was presented at the Institute's annual conference held in London on November 11 and 12, 1959.

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The grain-size of a material controls, to a large extent, its properties and formability. Control of grain-size, however, is not so easy in practice, but the use of grain-size limits in specifications will create an awareness of its importance, which could lead to more consistent quality of sheet metal, at least as far as structure is concerned. This paper was presented at the annual conference of the Institute of Sheet Metal Engineering, London, November 11 and 12, 1959.

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Control of Thickness of Metal Sheet and Strip **203**
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The authors explain the development of the rolling mill, continuous thickness measurement gauges and automatic gauge control in relation to the surmounting of the problems of bad shape and uneven gauge. This was a paper presented at the annual conference of the Institute of Sheet Metal Engineering, London, November 11 and 12, 1959.

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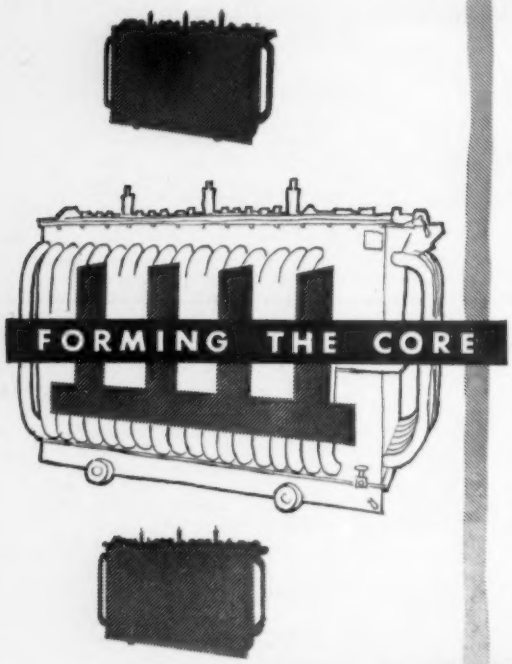

These 180 kW Birlec bell furnaces at the works of Joseph Sankey & Sons Manor Works Ltd., Wolverhampton, have been installed for the high temperature annealing of hot-rolled silicon steel sheet for transformer cores. Two more Birlec installations, totalling a further ten bell furnaces, form a substantial part of Sankey's annealing capacity. Some 450 tons of transformer sheet, with a finished value exceeding £36,000, are treated each week in Birlec Furnaces.

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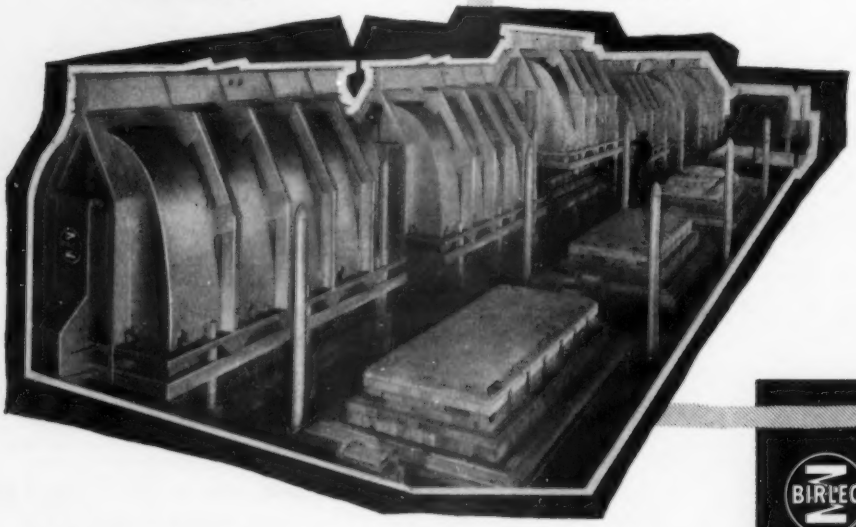

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PLAN FOR EXPORT

TODAY both Government and industry are increasingly conscious of their joint responsibilities in the promotion of economic growth, full employment and better standards of living, but these conditions can be arrived at only by the continued sale of British products in overseas markets. An insular attitude is quite out of place when the necessity is to support the rate of economic growth to which the community has now become accustomed.

It is unfortunate that, in industry, there is still too wide a gulf between understanding the need and translating this understanding into a practical planned programme for export trade development. Many companies have adopted the attitude that the export field is only a stop-gap remedy for reductions in home demand that may be brought about by economic recessions; but it should not be forgotten that a recession in this country is usually associated with a general decline in world trade. This attitude towards exporting is, from its very nature, bound to lead to failure and overseas markets can only be developed successfully by a rational and carefully planned effort.

The present Government has declared its confidence in British industry and it is therefore up to industry to accept this responsibility and show its acceptance by redoubling its efforts to secure a greater share of world trade.

There have been many learned dissertations given on the problems of exporting abroad, one of the most recent being that written by Mr. Sidney Roberts, managing director of Hoover Ltd., for presentation at the B.E.A.M.A. Domestic Appliance Export Sales Conference. In his address he gave many details of the methods of approach adopted by his company Of perhaps the greatest importance is that of intensive and *continuous* studies of the growth potentialities of world markets making it possible to determine the general strategy of each market, and to forecast national trends. He also suggests three broad methods of approach : infiltration with cooperative promotional activity by the company and handled through agencies or distributors ; the establishment of a subsidiary company (with nationals in charge of organization and management) which would be a selling organization and would be supported by intense promotional activity ; and the establishment of a manufacturing and sales subsidiary or, in special circumstances, the conclusion of agreements with a manufacturer under which a company's products would be produced on a royalty basis or under licence. Often the above methods are stages in a continuous process of market development.

Many other important facets were dealt with in the address, but it is the firm belief of Mr. Roberts that greater success in export can be achieved by the smaller companies if the " know-how " acquired by the larger organizations is used, if trade associations undertake international research to assist its members, and groups of companies combine together sharing common research and merchandising facilities. If these steps are taken the development of a healthy export trade as an element in the smaller company's production programme can be achieved without high expense. But to enter the export trade without the proper " tools " can only incur a high rate of failure.

INSTITUTE OF SHEET METAL ENGINEERING

Recent and Forthcoming Activities

SUCCESSFUL INSTITUTE LUNCHEON HELD IN LONDON

ANOTHER of the periodical Institute-Luncheons was held at the Cafe Royal, London, on January 27. At this function a gathering of members and visitors entertained Mr. E H. C. Leather, M.P., who subsequently addressed them, taking as his subject "Some Aspects of the Economics of Industrial Expansion." Mr. Leather made some highly pertinent remarks in his well-known pungent and forthright style, which were received with considerable enthusiasm by his audience and afforded much food for subsequent reflection.

WOLVERHAMPTON SECTION MEETING

OWING to the sudden illness of the lecturer and the inability to make alternative arrangements at short notice, the meeting of the Wolverhampton Section, which was scheduled to have been held on January 27, had to be cancelled. A notice of the cancellation was circulated to all members of the Section and of the Midland Branch, but the Wolverhampton Section Committee is conscious that this may not have reached all of its members in time. It wishes to express its apologies for any inconvenience that may have been caused by circumstances over which it had no control and hopes it may be possible to arrange for the lecture on "High Speed Blanking and Piercing" which was to have been delivered to be presented at a meeting on some future date.

INTERNATIONAL DEEP DRAWING RESEARCH GROUP MEETING IN PARIS

AS previously announced a colloquium on sheet metal-forming with special emphasis on methods of testing, organized jointly by the Société Français de Métallurgie and the International Deep Drawing Research Group, will be held in Paris from May 23 to 27, 1960, inclusive. The first three days of this meeting will be devoted to open sessions at which papers will be presented and discussed on Theoretical Studies of Sheet Metal Forming, Methods of Sheet Metal Testing, and New Techniques of Sheet Metal Forming. The final day will be taken up with closed meetings between delegates of member bodies of the I.D.D.R.G. at which the programme of investigational work for the ensuing year will be drafted.

It is anticipated that, in addition to the official British delegation to the I.D.D.R.G. meeting, a number of other members of the British Deep Drawing Research Group will wish to attend the open sessions. Details of the meeting will be circulated to all members of the Group, and to any others who signify their interest, as soon as these are available.

Addresses for Further Information

Requests for further information from interested persons in the U.K. can be made to the Hon. Secretary of the Institute of Sheet Metal Engineering, John Adam House, John Adam Street, Adelphi, London, W.C.2. Those in other countries should communicate with either member of the joint organizing Secretariat as follows :—

S.F.M.: M. M. Dupont, sécrétaire-général de la Société Française de Métallurgie, 25, rue de Clichy, Paris, 9eme.

I.D.D.R.G.: Dr. S. Garber, BISRA Laboratories, Hoyle Street, Sheffield, 3, Yorks (England).

INTERNATIONAL CONFERENCE ON COLD EXTRUSION OF STEEL

FOLLOWING the Conference organized by the Institute on The Cold Extrusion of Steel in 1953 interest in the process has been slowly growing in this country. There have been certain new developments in the field of tool materials, press equipment and applications, and plans are advancing for the staging of a further conference on the subject in the late Autumn of this year. It is proposed that this Conference should be on an international scale and offers of papers have already been made from overseas countries as well as from the U.K.

Further invitations have been and are being sent out to known experts in this field and offers of papers or suggestions in connexion with the Conference will be welcomed by the organizing sub-committee and should be addressed to the Hon. Secretary, ISME, John Adam House, Adelphi, London, W.C.2.

The Production of SPRING-STEEL STRIP at the Tipton Works of FIRTH CLEVELAND STEEL STRIP LTD.

USES for spring-steel strip both in the cold-rolled and hardened and tempered condition have steadily increased throughout the world in recent years. A leading firm engaged in the production of these materials is Firth Cleveland Steel Strip Ltd., of Tipton, Staffordshire, a member of the Firth Cleveland Group. Besides serving a great variety of industries at home this company has steadily increased its export trade and is regularly sending substantial quantities of the highest quality strip to the United States of America, Canada, Australia, China, Portugal and Italy in addition to a number of other markets.

The almost innumerable end uses to which this material is put would occupy too much space to describe here, but typical examples are: all types of saws, clock and gramophone springs, measuring rules, corset supports, piston rings, umbrella ribs, knives, chain side plates, fastenings and clips, trowels and pen nibs. The motor industry is widely served: indeed, the range of consuming industries which are dependent on this material for their production is constantly being added to.

The company has grown considerably in recent years, and particularly since its incorporation into the Firth Cleveland Group. Modern equipment enables it to offer an extensive range of sizes which includes widths from $\frac{1}{8}$ in. to 12 in., and in thicknesses from 0.004 in. to 0.092 in., in coils or cut lengths. Hardened and tempered spring-steel strip is available in a variety of finishes including grey or blue-black, polished white, polished blue and polished bronze. It can be supplied with edges sheared square, dressed square or dressed round. Cold-rolled spring-steel strip is normally supplied with a smooth bright finish in a choice of five tempers namely bright-annealed, pinch-passed, half-hard, hard-rolled and high-tensile. Edges are sheared square, rolled, dressed, ground or deburred as required. All steel is produced to fine limits and conforms to tolerances laid down in British Standard 1449-1956 and in special cases, to much finer limits.

The company now specializes in high-carbon

Fig. 1.—General view of pickling line from exit end (Chemical Engineering Contruction (Pensnett) Ltd.)

steel strip to the exclusion of all other cold-rolled products and by virtue of concentration on this, it is making great progress in this field.

Works Layout

The works are laid out in a series of parallel bays, the process in each bay being so arranged to feed the subsequent process in the adjacent bay. This arrangement allows for a line process method with the flexibility necessary for special operations or repeat processes.

The first bay is the steel store behind which lies the first processing bay where normalizing, scale breaking and pickling are carried out. This is followed by the annealing bay and parallel to, and adjacent to this are the rolling, slitting, length cutting, hardening and tempering, polishing, inspection and warehousing bays. The roll-grinding section, the machine shop and the engineering department lie to the rear of the production bays, and the administrative offices are placed at the front adjacent to the entrance to the works, where the laboratory and testing house are situated.

The steel stores hold a considerable volume of hot-rolled strip mostly in coils weighing approx. 20 cwt. each. This stock is made up of high-carbon steel, low-nickel-alloy steel, low-nickel-chrome and silico-manganese steel, which covers the range needed for the production of spring steel and saw strip as well as that required for fastenings, knives and most of the other general trades catered for.

Work Processes

Steel supply is under rigid quality control. All steel is bought against a comprehensive specification, and tested immediately on receipt for compliance with all aspects of this specification by the laboratory and inspection staff. Steel being charged into production is, therefore, released only against a clearance certificate.

Continuous Pickling Line

The raw material used in the cold-rolling processes is black hot-rolled strip in tightly wound coils. A skin of iron-oxide scale, from the hot rolling, covers the entire surface of the strip, and this must be removed before the surface can be improved by cold rolling.

Scale removal is achieved by loosening and cracking the brittle oxide layers by bending the strip through staggered flattening rolls. This operation is immediately followed by immersing the strip in hot sulphuric acid which pickles the surface completely free from scale.

Scale breaking and pickling is done on a continuous pickling line illustrated in Fig. 1. This comprises a staggered roller scale-breaking and flattening unit, manufactured by Fred Cam (Engineers) Ltd., followed by a strip joining arrangement prior to the actual pickle tank. The tank itself is of mild-steel plate, lined with rubber and internally lined with acid-resisting brick-work. Heating is by steam and the tank is completely covered and free from fumes. Two off-take ducts shown in the illustration conduct the fumes through

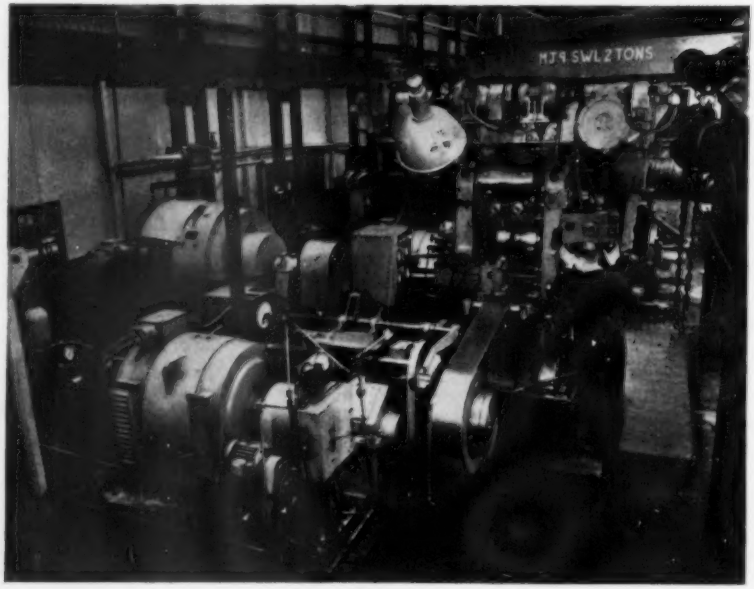


Fig. 2.—General layout of Farmer-Norton 4-high reversing mill. Other mills include a Farmer-Norton 4-high non-reversing mill, a W. H. A. Robertson 4-high non-reversing mill, and a Bronx Engineering 2-high non-reversing mill. Mill control switchgear was supplied by Contactor Switchgear Ltd.

a fume scrubber before discharge to atmosphere. The bath temperature is held at 85 to 95° C. and the pickling liquor is a 12 to 16 per cent concentration of sulphuric acid with suitable inhibitor additions. The lay-out of the pickling line, which was built by Chemical Engineering Construction (Pensnett) Ltd., provides infinitely-variable speed control of strip using equipment manufactured by C. J. R. Electronics Ltd., so that full output is possible according to the pickle-bath strength. Immediately following the pickle tank comes the high-pressure water washing arrangements fed at 100 lb. per square inch with specially designed spray jets which water blast the strip surface completely to remove acid and any residual adhering solids. Following this are steam jets which ensure that the pickled strip is warm and dry before oiling.

The strip take-up unit has power-breaking self-collapsible drums and power push-off. All operating controls are mounted on two adjacent panels for simplicity of control. The plant is designed to take two strips running side by side and to allow truly continuous operation two double-armed uncoilers and four recoilers are provided.

Strip speed varies according to the iron content of the pickle bath and the arrangement allows for infinite variation between 10 and 60 ft. per min. The pickling is at optimum efficiency with 0.5 per cent iron in the bath and there is no apparent loss in pickling speeds up to 3.5 per cent iron provided that the acid strength is maintained at 12 to 16 per cent sulphuric acid (by wt.). It is found that when the iron solution in the liquor increasedto 4.5 per cent then there is a rapid progressive fall in pickling rate with further increases of iron.

The bath liquor is usually discarded at this point for pickling speeds fall below the economical minimum of 15 ft. per min. Bath temperatures are maintained at 85 to 95° C. the higher temperatures being used as iron content increases.

Up to discard, an average of 200 tons of strip are pickled with a weight loss of approximately 0.6 per cent., due to scale removal, the process requiring 800 gallons per cycle of B.O.V. acid. Much of the hot-rolled scale does not go into solution in the acid, the ferrous oxide (FeO) layer adjacent to the unoxidized metal being the most easily dissolved. With a normal structure of the scale, the acid attack proceeds under the insoluble outer layers of ferric oxide (Fe_2O_3) to dissolve the ferrous oxide (FeO). The beneficial effects of scale breaking to crack the outer layers and expose the soluble inner oxides are obvious.

Daily control checks by the laboratory staff are made on the acid strength and on the iron content of the bath.

Cold Rolling

Even after the pickling process hot-rolled carbon-steel strip has a great number of limitations, the most important being as follows :—

(1) The surface finish is dull and coarse ;

(2) Dimensional tolerances are wide in both the width and the thickness ;

(3) Mechanical properties are poor, the strip being relatively hard and brittle ;

(4) The sizes obtainable are limited, 0.064 in. being the minimum thickness ;

(5) The metallurgical structure is not ideal for the batch hardening processes where heating cycles must be economically short (Fig. 8).

These limitations are removed by cold rolling with its attendant processes, giving a strip steel available in a wide range of widths, and thicknesses and mechanical properties which may be tailored to fit the various manipulation, presswork and heat-treatment processes used by customers.

Cold rolling is carried out on five mills of varying capacities. Three of these are of the 4-high type with one of them having reversing facilities. This mill has 6-in. diameter work rolls and 17½-in. diameter back-up rolls by 16-in. wide barrels. It possesses infinitely-variable speed control with a maximum strip speed of 1,000 ft. per min. All mills are fitted with Taylor, Taylor Hobson " Flying Mikes " enabling adequate control of gauge to be carried out ; tolerances of ±0.001 in. can be maintained and by special techniques it is possible to work to half of these tolerances. The reversing mill is also fitted with Elliott Bros. (London) Ltd. load meters which give an indication of the bearing load in tons to the roller. The reversing-mill motor rating is 300 h.p. d.c. and the mains supply is provided by an English-Electric Ward-Leonard motor-generator set feeding the mill and coiler motors and having a rating of 500 h.p. at 985 r.p.m. Inertia exciters give the necessary compensation during acceleration and deceleration. A cold soluble-oil system is in use with a Serck Radiators cooling system for controlling temperature and filtering is by Alfa-Laval centrifuge. Mill drives were manufactured by the English Electric Co. Ltd.

High-carbon steels make up the throughput on these mills and owing to the high hardness and brittleness as hot rolled, the strip has to be handled very carefully. The first reductions after pickling are light; no more than 20 per cent reduction in thickness is attempted usually taking two passes through the rolls. If heavier reductions are tried the result is often edge cracking due to over-rolling. Annealing operations must be introduced to enable the gauge to be reduced further and due to progressive breakdown of the carbides by this heat treatment, the cold reductions may be increased after each anneal (Fig. 8).

With increase in the carbon content in the steel, the ductility decreases and therefore the rolling reductions between annealings are smaller in

proportion. Often a steel containing 1 per cent carbon will have to be removed from the rolling mill two or three times before an overall reduction of thickness of 50 per cent can be achieved.

Typical rolling procedure on 0.70 per cent carbon and 1 per cent carbon steels are given in Table I.

TABLE I—*Typical Cold Rolling Reductions with Annealings as Applied to 0.70 per cent and 1 per cent Carbon Strip*

Op. No.	Fircleve 1/70 (0.7 per cent c)	Op. No.	Fircleve 4/105 (1.05 per cent c)
	Hot-rolled Strip 12g		*Hot-rolled Strip* 12g
1	Pickle	1	Anneal 690° C.
2	Cold Roll to 0.080 in. (23 per cent)	2	Pickle
3	Anneal 690° C.	3	Cold Roll 0.095 in. (9 per cent)
4	Cold Roll to 0.056 in. (30 per cent)	4	Anneal 690° C.
5	Anneal 690° C.	5	Cold Roll 0.075 in. (21 per cent)
		6	Anneal 690° C.
		7	Cold Roll 0.053 in. (29 per cent)
		8	Anneal 690° C.

Roll Grinding

The finish of cold-rolled strip is directly dependent on the ground finish of the rolls through which it passes, the surface pattern of the very hard rolls being directly transmitted to the softer strip steel. Very high loads are used to cold-reduce the strip and these cause slight bending of the rolls.

In order to present a flat roll surface to the strip when under load, the rolls must be ground very slightly barrel shaped ; this roll camber is measured in thousandths of an inch.

Since the surface condition and shape of the strip is all important, roll grinding is done within the works. The main item of equipment used is a Naxos Union 500/1,000 roll-grinding machine. This provides facilities for producing degrees of roll surface from matt to mirror finish. A very fine feed arrangement is obviously necessary to obtain the high-quality surface finish essential to rolling this class of material, and the roll grinder is fitted with a micrometric back-feeding arrangement enabling back-feeds as minute as two millionths of an inch to be applied.

The camber grinding arrangement of the Naxos Union machine allows for the reproduction of flat faces or of convex and concave curves in parabolic, sine, bending or empirical lines so that a roll shape matching the requirements of the strip can be produced to allow for the highest degree of flatness in the strip being rolled.

Annealing

The annealing process is used to soften the strip by removing the cold work hardening induced by the previous rolling. This enables further cold reduction to be made without causing edge cracking. On high-carbon steels, the process of cold rolling, followed by annealing also has the effect of breaking down the original hard, brittle hot-rolled structure of pearlite, replacing it with spheroidized carbides (*see* Fig. 8).

It is only by repeated cold rolling and annealing that the maximum ductility can be imparted to carbon steels and so enable the consumer successfully to carry out difficult presswork and forming operations. The combination of these processes break down and ball-up the hard carbides in the steel and so provide an ideal structure for the batch hardening usually carried out by the consumer, following his manipulation processes.

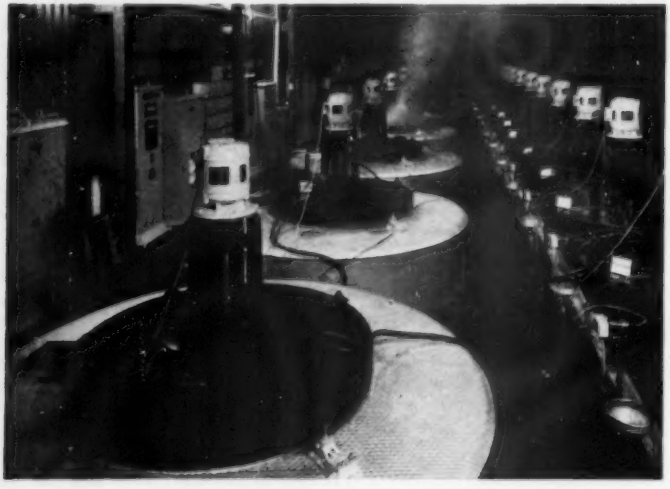


Fig. 3.—Bank of G.E.C. pot-type annealing furnaces. The controlled atmosphere is supplied by a towns-gas burner with an output of 1,000 cu. ft. per hour. Temperature control in the annealing section is by Cambridge and Foster instruments

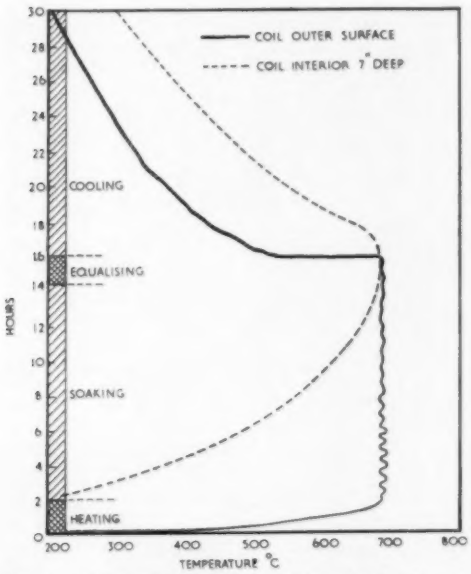


Fig. 4.—Temperature gradients during the heating and cooling of a charge

The annealing equipment consists of 11 pot-type G.E.C. bright-annealing furnaces with ratings varying between 110 and 180 kVA. each controlled by automatic temperature controllers with indicating and recording instruments, the closeness of control being $\pm 3°$ C. A protective gas atmosphere suitably cleaned and dried is fed to the pots during the purging, the heating, and cooling cycles of the annealing being maintained to ensure uniform brightness together with uniform heat distribution within the charge of steel. Each pot head has a forced recirculation fan fitted and the head is effectively sealed against gas leakage by a water-cooled rubber-ring seal.

Each furnace is capable of annealing a 6-ton charge of steel in coil stacks of 48 in. diameter by 60-in. in height. The weight of the charge is carried on a specially designed heat-resisting-steel base suspended from the head by three separate bars, the whole being enclosed inside a heat-resisting steel shell or envelope for the purpose of retaining the protective gas atmosphere. The annealing shop is serviced by two 7½-ton overhead cranes which are floor controlled by means of suspended pendants.

All the annealing carried out on these steels is subcritical, *i.e.*, the temperature is never allowed to rise above the lower critical (727° C.), though this temperature is approached as closely as industrial processes allow; 690 to 700° C. gives the optimum annealing with safety, and all the annealing is carried out at this temperature.

When annealing large, tightly wound coils of strip, the heat transfer is very poor throughout the mass of steel. This is due to the insulating effect of the minute air gaps between each lap of strip, making long soaking times essential to obtain uniform heat distribution. Fig. 4 shows the temperature gradients within a charge of large strip coils. This information was obtained by using probe thermocouples which were, in some cases, inserted down bore holes in the coil walls. It may be seen that with a normal 16-hour heating cycle, the coil does not reach the uniform controlled temperature until the last hour. Carbide spheroidization which is very slow below 650° C., only takes place in the last five hours at the coil centre.

Quality control is achieved by the daily inspection of annealing temperature records and by a routine metallographic check on every charge. The controlled atmosphere is regularly analysed for all oxidizing gases CO, CO_2, H_2O and O_2 the proportions of which regulate the bright annealing of the charge. Table II shows a typical analysis of the gas as fed into the furnaces.

TABLE II—*Composition of Exothermic Controlled Atmosphere, as Compared to the Parent Town's Gas. Mixture Ratio of 2.3/1 Air/Gas*

Composition	Raw Town's Gas	Burnt Town's Gas
	Per cent	Per cent
Carbon dioxide ..	4.4	7.1
Carbon monoxide ..	15.8	8.3
Oxygen	0.6	0.0
Hydrogen	51.7	12.4
Methane	17.9	0.2
Illuminants	1.6	Nil
Water vapour ..	25° C. Dew Point	∠ 0° C. Dew Point
Nitrogen	Balance	Balance

Strip Hardening and Tempering

The range of hardness and tempers obtained by cold rolling and annealing, is designed to give the optimum mechanical properties for the customers' manipulation process, be it deep forming or flat blanking. After manipulation the majority of components manufactured from carbon spring steel, are given a heat treatment designed to increase the hardness and springiness.

Many applications do not require severe forming or bending before heat treatment and often it is found to be of great advantage to use strip which is already hardened and tempered. Typical of such applications are handsaws, bandsaws, trowels and putty knives, where the only manipulation carried out is blanking, piercing and tooth setting. (Fig. 7).

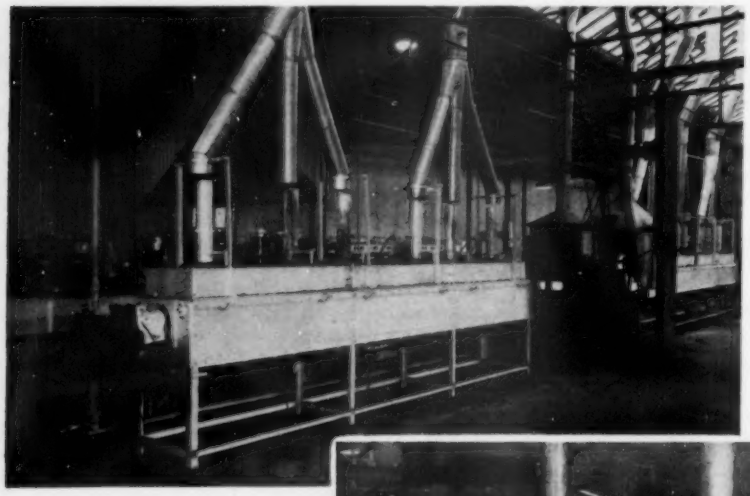


Fig. 5a (left).—Brayshaw gas furnace

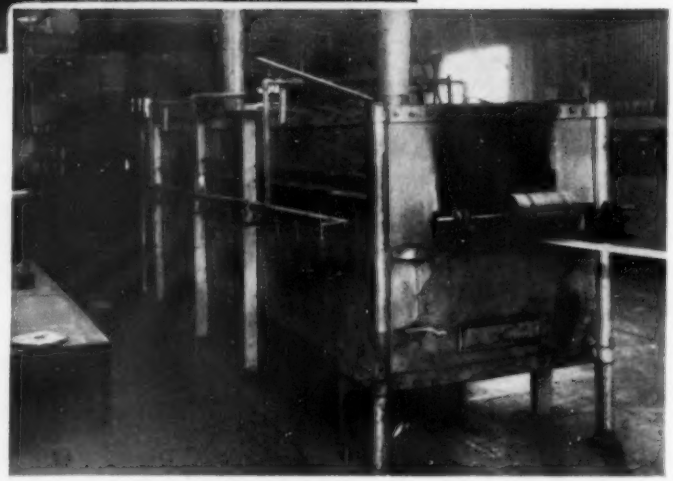


Fig. 5b (below).—Efco continuous electric furnace fed with protective atmosphere from 1,500-cu.ft. exothermic gas plant

The main benefits to be gained by using hardened and tempered strip are as follows:—

(1) No heat treatment is required in the customers' processing, therefore, eliminating costly plant and the dangers of distortion and discoloration associated with batch hardening;

(2) Continuous hardening and tempering of strip ensures that the physical properties are uniform throughout a coil and a batch. This uniformity is passed to the components manufactured from this type of strip;

(3) Flatness and straightness of the strip can be guaranteed to very high standards;

(4) A variety of high-grade finishes can be supplied, from a fine bright polish to a dense unpolished blue. In many cases this eliminates the expensive glazing and barrelling operations usually carried out on batch hardened components.

Modern press-tool design and tool steels allow the blanking and piercing of hardened and tempered strip at very high hardnesses. It is common practice, when producing high-grade trowels or textile components, to operate on strip which has been hardened to over 600 V.P.N. and 130 tons per square inch tensile strength.

The hardening and tempering section of the factory absorbs one third of the total production of the cold-rolling department. There are eight hardening and tempering units which are designed to heat treat sizes between $\frac{1}{8}$ in. and 12 in. wide, in single or multiple strands (Figs. 5a and 5b).

The furnaces are gas or electrically heated, the treatment temperatures being precisely controlled by automatic temperature-measuring instruments to ensure a uniform rate of heating is maintained on the strip being processed.

To avoid marring the original bright cold-rolled surface of the strip, the furnaces are of the muffle type which allows a feed of exothermic protective atmosphere to eliminate scaling at the hardening temperatures (Table II).

Besides the normal flat strip hardening and tempering, the heat treatment of concave and section strip is also undertaken. Two special furnaces have been laid down for this work. A typical process is the continuous treatment of umbrella ribs which are formed, hardened and

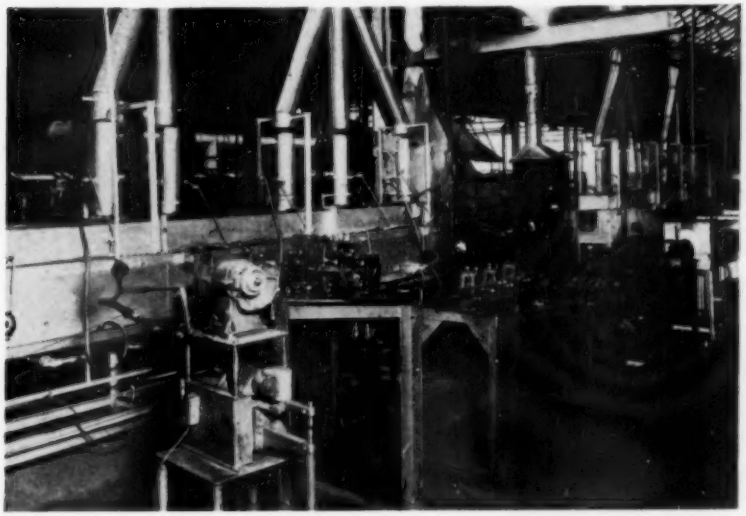


Fig. 6 (left).—Ingoing end of specially designed line for hardening and tempering section formed strip. The electric furnace was manufactured by Wild-Barfield Electric Furnaces Ltd.)

Fig. 7 (below).—Effect of tempering on hardness of 0.8 per cent carbon steel with some end uses

tempered and cut to length in one operation (Fig. 6).

Quality control utilizes hardness and bend testing with tensile and metallographic checks where these are required by the end product.

Finishing Operations

Slitting

As all the products from the cold rolling mill must be either edge pared or slit into multiple strips five high-speed slitting machines manufactured by Fred Cam (Engineers) Ltd. are used. Each of these is capable of slitting coils of about 1 ton so that the slit coil weight is dependent on the finished width. The process gives a clean square edge to a width tolerance of ±0.005 in.

Length Cutting

Where long continuous coils of strip cannot be used straight flat lengths are produced on two length-cutting machines supplied by Sir James Farmer Norton and Co. Ltd.

On the high-speed machine, pieces varying between 2 ft. and 12 ft. are flattened and cut to length. A special machine capable of cutting lengths from a few inches up to 20 or 30 ft. has been developed. The high-speed machine cuts widths up to 12-in. wide, but the special machine is limited to 9 in. maximum width. Tolerance of ±⅛ in. on the nominal length are usually guaranteed.

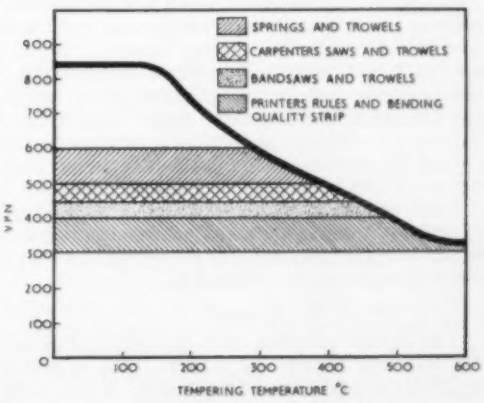
Edge Dressing

Where steel is required for use as a spring, a round edge is essential to minimize areas of local stresses which occur at any sharp angle on the edges. There are four edge-dressing machines which are capable of producing round edges up to 0.080-in. thick and square edges up to 0.080-in. thick.

Polishing

About two-thirds of the product from the hardening and tempering units is finally polished. This finish is required for various reasons among them being the dissipation of surface stress in springs, to permit the effective use of lubrication, and not least to give a fine appearance to the finished steel.

There are four strip-polishing machines which have been developed here to give a range of surface finishes varying from about 25 micro-inches to as fine as 3 micro-inches, the latter being equivalent to a mirror finish.



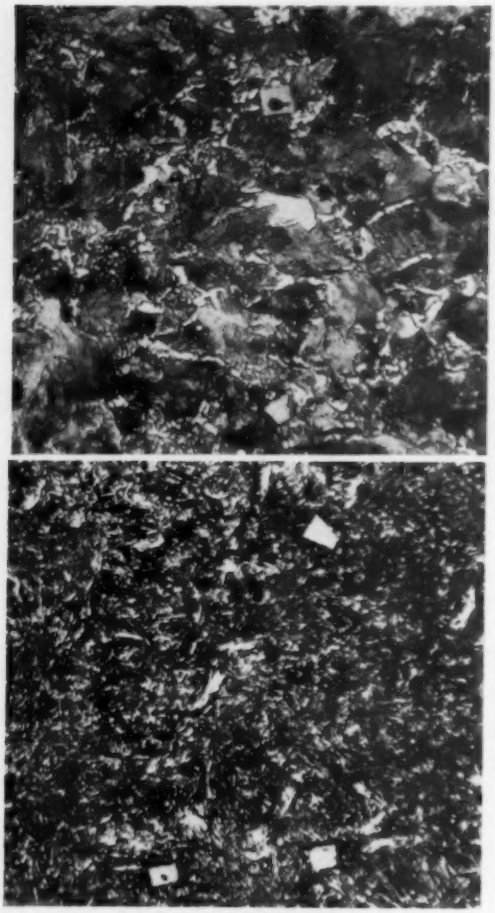


Fig. 8 (×750).—Photomicrographs showing the effects of hot rolling (above left), annealing (above) and hardening (left) on steel

Testing and Inspection

Besides the chemical checks on analysis already referred to, physical and mechanical tests are carried out on all steel passing through. Tensile testing, bend testing and hardness testing equipment is in constant use both during works processes and also at the final inspection stage. Final inspection of these high-grade steels is carried out over motorized benches each of which is fitted with demagnetizing heads and oiling arrangements.

Final inspection of all products is carried out adjacent to the wrapping and warehousing section so that adequate protection of the wrapped material awaiting despatch is maintained.

Service

The works technical staff is always available for customer service and advice. The technical problems which arise amongst users of this class of materials are of sustained interest to the staff, and arising out of past liaisons have come useful developments to production techniques both here and amongst users.

One such development concerns the machine press blanking of non-ferrous and mild-steel sheet and strip, particularly where it is uneconomical to use conventional press tools on small job lots. This development makes use of the well-known method for cutting out cardboard cartons, cigarette packets and shoe leather, where the tool is formed from hardened steel strip mounted in a base of resin-bonded laminated wood. These tools are known as cutting formes, the hardened and tempered strip being bent and shaped to the contour of the blank required. A male and female forme makes up the tool with rubber dowels on each side of blades to act as strippers.

By using high-duty strip in the blades and by reinforcing the tool base, these special cutting formes are proved to have considerable advantages of versatility and low cost over conventional tools, when blanking sheet or strip metal.

This combination of experience and co-operation between consumer and supplier which has given rise to this and similar beneficial exploitations of the properties of spring steel strip will continue to be an important facet of the company's activities.

POWER PRESS EXHIBITION

The Sixth Gauge and Tool and Power Press Exhibition to be organized by the Gauge and Tool Makers' Association will be held at Olympia, London, from Monday, October 1, to Wednesday, October 10, 1962.

INDUSTRIAL STANDARDS of ACCURACY in DIAMOND-PYRAMID INDENTATION HARDNESS MEASUREMENT

Second Report of the Testing and Measurement Sub-Committee

Chairman : J. F. KAYSER

(*A paper presented at the Annual Conference of the Institute of Sheet Metal Engineering, London, November, 11 and 12, 1959.*)

THE first investigation by the I.S.M.E. Hardness Testing Committee into the standard of hardness testing procedure in industry which was reported in 1957 showed that most users of hardness testing machines were unable to determine the hardness of thin metal specimens (say, 0.02 in. and less) with any approach to accuracy. In many cases the surface was not properly prepared and too heavy a load was used. The nature of the investigation, however, was such that it did not show the accuracy with which the impressions were being read and so a further investigation has been made to determine this.

Sixty-six firms took part in the test and since it was not possible to send the same block to all of them, 20 blocks were prepared by one of the referee laboratories. The impressions on some of the blocks were read by only one firm while others were read by five of the firms. Finally, the referee laboratories read all the impressions.

The test blocks were $\frac{3}{4}$ in. diameter cylinders, $\frac{1}{2}$ in. high ; one surface was given a micro-polish and three impressions (approx. 800μ, 300μ and 70μ respectively) were made upon it. Each block was packed in a small pill box. All the results are given in Table I.

General Conclusions

The general conclusions of the committee* are as follows :—

(1) From the results it appears that it is not yet possible to assign a unique hardness value to a metal from measurements of applied load and diagonal length, because of the errors incurred in measuring the latter.

(2) Different laboratories report significantly different values for one and the same diagonal, and in one case industrial users showed a greater degree of agreement than the referee laboratories.

(3) In the case of strip or sheet with a hardness in excess of say 750 HV and which is so thin that a load in excess of 10 kg. should not be used, the range of readings is so great that it is felt that diamond pyramid indentation tests should not appear in specifications of such material.

(4) The findings are in general agreement with that of Dipl.-Ing. Madame Slavina of the U.S.S.R., who recently reported that a range of 3μ (0.5μ Standard Deviation) was to be expected. With a hardness of 750 HV and loads of 5 kg., $2\frac{1}{2}$ kg. and 1 kg. this corresponds to a hardness range of approximately 45, 65 and 100 HV units respectively.

Discussion of Results

1. *Large impression* (800μ *approximately*)

The participating firms showed a range of 48μ (using the standard $\frac{2}{3}$ objective on the Vickers hardness testing machine 1 ocular = 1μ) and the referee laboratories a range of 22.5μ. If one assumes a load of 50 kg. these figures correspond to a range of approximately 20 HV units and 10 HV units respectively.

2. *Medium impressions* (300μ *approximately*)

The participating firms showed a range of 17.5μ and the referee laboratories a range of 9.5μ. If one assumes a load of 30 kg. these figures correspond to a range of approximately 90 HV units and 50 HV units respectively.

3. *Small impressions* (70μ *approximately*)

The participating firms showed a range of 7.5μ and the referee laboratories a range of 12μ. If one assumes a load of 2 kg. these figures correspond to a range of approximately 200 HV units and 480 HV units respectively.

Disturbing as is the wide variation of readings between the different referee laboratories, the

* One member of the committee dissented from the findings of the committee and his comments are listed in Appendix 3.

TABLE I

	Readings by Member Firms				Readings by Referee Laboratories			
Sample	Firm No.	Impression Large	Impression Medium	Impression Small	Laboratory No.	Impression Large	Impression Medium	Impression Small
2	1	801	303	72.5	1	787.5 795 792.5	299.5 301 301	67 71 69
	25	804 794.5	304 303	71 73.5	2	800.5	302	71.5
	33	797	300.5	66.5	3	803.5	303	71.5
	44	794.5	297.5	69	4	796.5 797.5 798	299 301 301	70 72.5 69.5
	64	799.5 799	303 302	72 71	5	802	303	71
3	2	781	286.5	70	3	783.5	284.5	68
					5	781	284.5	68.5
4	3	769	279.5	64	1	764 765 765	277.5 277 278	63 64 65
	23	767.5	279.5	64.5	2	763.5	279	65
	31	769	280.5	65.5	3	769.5	280	64
	45	769	281	66.5	4	763.5 764 759	278.5 279.5 275	66 64.5 62
					5	770	279	65
5	5	764	277.5	67	1	761.5 761 759	273 271 273	61.5 63 64
	21	762.5	276.5	66.5	2	761.5	277	65
	39	764 764	276 276.5	67.5 65.5	3	767.5	278	65.5
	43	757	276.5	67	4	761 759.5 757.5	270 270.5 270.5	64.5 65 61.5
	60	765	275.5	65	5	765	276.5	65
6	6	776	292	67.5	3	783	292	66.5
	32	779	292	67.5	5	779.5	291	66
7	7	791.5	297.5	69	1	792 793 790	296 297 298	70 70 68
	35	794	299	69.5	2	795.5	298	70.5
	40	792.5	298.5	69	3	799.5	298.5	70
	47	795	297	69	4	794 792 790	297 297 296.5	69.5 70 70
					5	798	299	70
8	8	773	285	67	1	776 773 773	284 286 284.5	67.5 67 66
	30	771.5	286.5	69	2	774.5	287.5	68
	42	772	272	62	3	780	289	68.5
	61	780.5	289.5	69.5	4	773.5 774 772	287 287 285.5	68 69 65.5
	63	776	287	69	5	778	288	68
10	9	787 784.5	297 294	71.5 71	3	790.5	297.5	72
	54	787.5	298.5	74	5	789	298	72
11	10	761.5	287.5	67	1	758.5 761 760	284 286 284.5	66 66 65
	34	761	286	67.5	2	764.5	292	67.5
	56	761.5	288.5	69	3	766.5	289	66.5
	58	762.5	287	67	4	760.5 760 759	286 287 284.5	65.5 66 64
	59	765	291.5	68.5	5	765	288	66
12	11	771	277	64.5	3	771.5	278.5	63.5
					5	772.5	278	64

TABLE I—*continued*

Sample	Readings by Member Firms: Firm No.	Impression Large	Impression Medium	Impression Small	Readings by Referee Laboratories: Laboratory No.	Impression Large	Impression Medium	Impression Small
13	12	793.5 799	287.5 290.5	67 67.5	3	799.7	291.2	67.7
	26	790 791.5	290 289.5	68.5 68.5	5	796	290	67
	36	751	291	71				
	57	798	292	69.5				
14	13	783	291	69.75	1	778 777 777	282 284 283	62 64 63.5
	27	—	285	68.5	2	780	286.5	67
	49	778	288	67.5	3	785.5	288	66
	51	780.5	287	66.5	4	777 778.5 774.5	284 284.5 284.5	63 64 61
	65	779 783	286.5 289	66.5 66.5	5	783	287	66
15	53	782	295	70.5	1	765 769 766	293.5 293 293	68.5 68 68.5
	14	784.5	295.5	71	2	783.5	295.5	70.5
	29	784	297	69.5	3	787.5	298	70
	55	783	296.5	70.5	4	779 781.5 778	294.5 294.5 292.5	69.5 70 69
	66	784.5	297	71.5	5	786	296.5	69.5
16	4	762	279.5	65	1	756.5 756 755	274.5 274 275	62.5 63 63.5
	15	753	273	62	2	758	276.5	63.5
	41	757	277	64	3	762.5	278	63.5
	50	760	278	64	4	755 756 755	274.5 275.5 271	63 63.5 62
					5	760	277	63.5
17	16	784	292		1	794 792 792	293.5 293 292	67.5 67 67
	24	795.5 796.5	296.5 298.5	69 69.5	2	794.5	295.5	68.5
	37	797	296	69	3	802	297	67.5
	46	795	299	69	4	794 794 792	294.5 296 295.5	68.5 67 65.5
					5	798	296	68
18	17	774.5 776	276.5 277.5	63 62.5	1	769.5 766 764	272.5 272 269	54.5 57 52
					2	775.5	276.5	64
					3	779	278.5	64
					4	771.5 773 768	275.5 278 276	63.5 64.5 64
					5	776.5	278	64
20	18	790.5	300.5	74	1	788 787 782	294 295 291	69.5 68 69.5
	19	789.5	296	71	2	790.5	295.5	69.5
	28	—	—	69	3	796	296	69
	52	791.5	297	71	4	791 791 790	293 296 298	71.5 71.5 68
					5	791	296	69
21	20	778.5	289	68.5	1	777 779 775	287.5 287 288	66.5 67 67
	22	780	290	70	2	780.5	289.5	68.5
	38	781.5	289.5	69.5	3	785	290.5	68.5
	48	780	288.5	68	4	777.5 778.5 773.5	287 287.5 288	69 69 67.5
	62	782.5	282.2	71.5	5	783	289.5	69

variation of readings within the same laboratory is still more disturbing. For example, one laboratory reported readings on one impression by three different observers of 787.5μ, 795μ and 792.5μ *i.e.*, a range of 7.5μ.

This was discussed at length and the committee were of the opinion that the samples had not been treated with sufficient care. Removal of dust by rubbing with a dirty duster was mentioned and the packing of the samples for transport was often poor. As a result the samples became badly scratched making it difficult to obtain satisfactory readings. In many instances the small impressions were virtually obliterated.

It was hence decided that another series of test pieces be prepared and submitted to the referee laboratories and to the National Physical Laboratory. Three samples each carrying three impressions (and a carrying case) were prepared and are illustrated in Fig. 1 which also shows one of the samples used during the first part of the investigation.

The samples were taken to the various referee laboratories by the Hon. Secretary to the Hardness Testing Committee and collected by him a few hours later. They were not, however, measured in his presence. Finally, the three samples were sent to the National Physical Laboratory where the nine impressions were measured. All the results are given in Table II and plotted in Figs. 2, 3 and 4.

Laboratory No. 1 measured the impressions on a standard Vickers hardness tester. Each impression was measured by four different operators.

Laboratory No. 2 used two operators. Operator No. 1 measured the impressions on a standard Vickers machine, a Tukon machine and on a Reichert microscope. The second operator used a standard Vickers hardness tester and a Tukon hardness tester.

Laboratory No. 3 used a standard Vickers hardness tester and the impressions were measured by three operators.

Laboratory No. 4 used three operators. Two of them used a Zwick hardness tester and the third operator a standard Vickers machine. When using the Zwick the small impressions were measured at 400 diameters, and the larger impressions at 200 diameters.

Laboratory No. 5 report only one reading and used a standard Vickers hardness tester.

Laboratory No. 6 used three operators each using a standard Vickers hardness tester.

Fig. 1

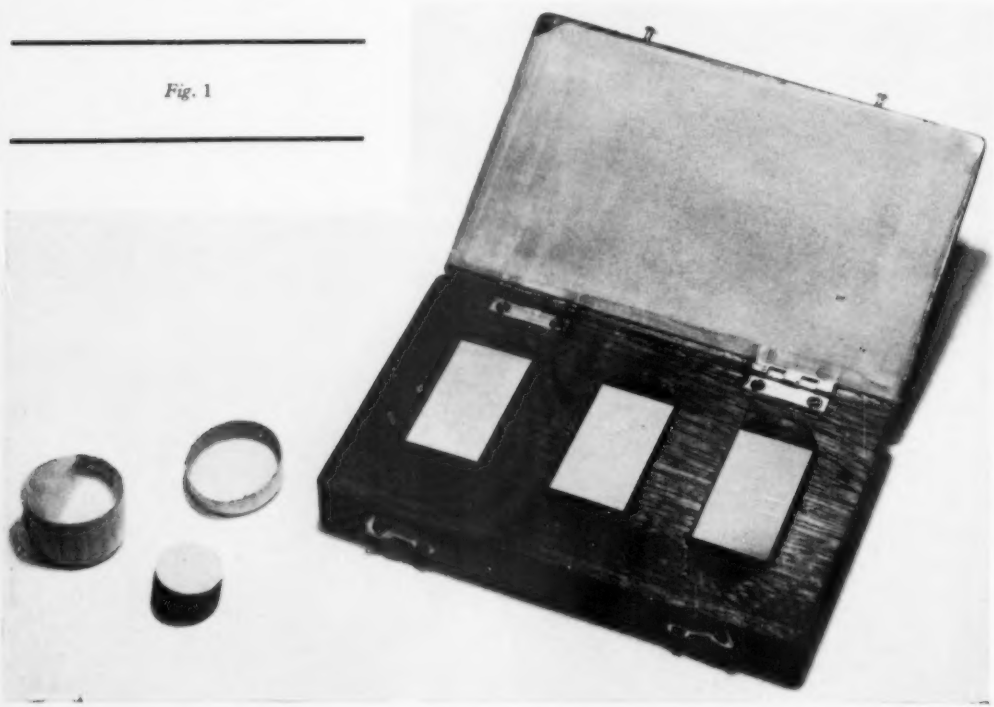


TABLE II—*Readings by Referee Laboratories*

Laboratory	Sample No. 7692									Operator No.	Machine
	Large			Medium			Small				
	V	H	M	V	H	M	V	H	M		
1	452	454	453	251	252	251.5	79	78	78.5	1	Vickers
	451	454	452.5	251	253.5	252.25	78	77	77.5	2	,,
	449	451	450	250	251	250.5	75	77	76	3	,,
	452	453	452.5	250	251	250.5	78	78	78	4	,,
2	450.5	451.5	451	251.5	251.5	251.5	77.5	77.5	77.5	1	Vickers
	454	456	455	251.5	253	252.25	76.9	77.4	77.2	1	Tukon
	454	457	455.5	250.5	251.5	251	76.4	77	76.7	1	Reichert
	451	451	451	250	250	250	76.5	76.5	76.5	2	Vickers
	455	456	455.5	252.5	253.5	253	77.9	77.3	77.6	2	Tukon
3	450.5	452	451.25	250.5	251	250.75	77	77	77	1	Vickers
	453	453	453	252.5	252	252.25	78.5	78	78.25	2	,,
	451	451.5	451.25	250	250	250	77	77	77	3	,,
4	456	456	456	254	254	254	77	77.5	77.25	1	Zwick
	455	455	455	253.8	253.8	253.8	77.5	77.25	77.4	2	,,
	—	—	—	250	251	250.5	77	78	77.5	3	Vickers
5	453	453	453	251.5	251	251.25	78	78	78	1	Vickers
6	453	454	453.5	251	252	251.5	76.5	77	76.75	1	Vickers
	453.5	454.5	454	252.5	251.5	252	77	77	77	2	,,
	455	454	454.5	252.5	251.5	252	77.5	76.5	77	3	,,
National Physical Laboratory	453.2	454.1	453.65	251.8	252.3	252.05	76.9	76.9	76.9		

V—Vertical. H—Horizonal. M—Mean.

Laboratory	Sample No. 7693									Operator No.	Machine
	Large			Medium			Small				
	V	H	M	V	H	M	V	H	M		
1	449	450	449.5	250	251	250.5	77	76	76.5	1	Vickers
	449.5	450.5	450	249.5	250.5	250	75	76.5	75.75	2	,,
	448	449	448.5	248	249	248.5	74	74	74	3	,,
	449	449	449	250	250	250	74	75.5	74.75	4	,,
2	451.5	451.5	451.5	251.5	251	251.25	75.5	76	75.75	1	Vickers
	453	454	453.5	251	252.5	251.75	75.6	75.9	75.75	1	Tukon
	450	451.5	450.75	249	250.5	249.75	74.9	74.2	74.5	1	Reichert
	448	449	448.5	249.5	249.5	249.5	75.5	75	75.25	2	Vickers
	455	456	455.5	251.5	254.5	253	75.9	75.9	75.9	2	Tukon
3	449.5	450	449.75	250	250.5	250.25	75.5	75.5	75.5	1	Vickers
	451	450	450.5	251	251	251	76.5	76.5	76.5	2	,,
	449	449	449	250	250	250	76	76	76	3	,,
4	452.5	453	452.75	253.5	253	253.25	75	75.25	75	1	Zwick
	453.5	453.75	453.6	252.5	252.75	252.6	75	75.25	75.1	2	,,
	—	—	—	250	250.5	250.25	75	75.5	75.25	3	Vickers
5	451	451	451	250.5	251	250.75	75	76	75.5	1	Vickers
6	451	452	451.5	250	251	250.5	74.5	75	74.75	1	Vickers
	452.5	451.5	452	251	251	251	75	75	75	2	,,
	452	451	451.5	251.5	250.5	251	75	74.5	74.75	3	,,
National Physical Laboratory	451.1	451.7	451.4	250.7	251.3	251.0	74.7	74.9	74.8		

V—Vertical. H—Horizontal. M—Mean.

TABLE II—*Readings by Referee Laboratories—continued*

Laboratory	Sample No. 7694									Operator No.	Machine
	Large			Medium			Small				
	V	H	M	V	H	M	V	H	M		
1	448	450	449	250	250	250	76	76	76	1	Vickers
	449.5	451	450.25	249.5	250	249.75	73	74.5	73.75	2	,,
	448	449	448.5	247	249	248	74	73	73.5	3	,,
	449.5	449.5	449.5	250	250	250	74	75	74.5	4	,,
2	450	451	450.5	250.5	250.5	250.5	75.5	75	75.25	1	Vickers
	453	454	453.5	251	252.5	251.75	75.2	75	75.1	1	Tukon
	452.5	451	451.75	249.5	248.5	249	75.2	74.2	74.7	1	Reichert
	450	450.5	450.25	249	249.5	249.25	75.5	75.5	75.5	2	Vickers
	453	457	455	251.5	254	252.75	75.6	75.8	75.7	2	Tukon
3	449	450	449.5	249	249	249	74.5	74.5	74.5	1	Vickers
	450	450	450	251	251	251	76	76	76	2	,,
	448	448	448	248	248	248	75	75	75	3	,,
4	452	453	452.5	252	251	251.5	74.25	74.5	74.5	1	Zwick
	453.5	454	453.75	252	252	252	74.5	74.75	74.6	2	,,
	—	—	—	249	250	249.5	74.5	75	74.75	3	Vickers
5	450	450	450	250	250.5	250.25	75	75.5	75.25	1	Vickers
6	451	450.5	450.75	250	249.5	249.75	74	74.5	74.25	1	Vickers
	451	451	451	250.5	250	250.25	74.5	74	74.25	2	,,
	451.5	450.5	451	250.5	250	250.25	74.5	74.5	74.5	3	,,
National Physical Laboratory	450.3	451.0	450.65	250.2	250.1	250.15	73.9	73.9	73.9		

V—Vertical. H—Horizontal. M—Mean.

The National Physical Laboratory used the measuring microscope that has been developed by Dr. J. C. Evans and his colleague Mr. R. S. Marriner.

Considering first the measurement of the large impression the highest average range was reported by Laboratory No. 2, *i.e.*, 5.42μ. The size of the large impressions was approximately 450μ which is the size of impression that would be obtained when testing annealed high-speed steel with a load of 30 kg.; and in this range an error in the reading of 5μ corresponds to a difference of only 6 HV units.

In the case of the medium-sized impressions, Laboratory No. 2 again had the highest average range, *viz.*, 3.42μ. The medium-size impressions were approximately 250μ and with a load of 30 kg. such an impression would corre-

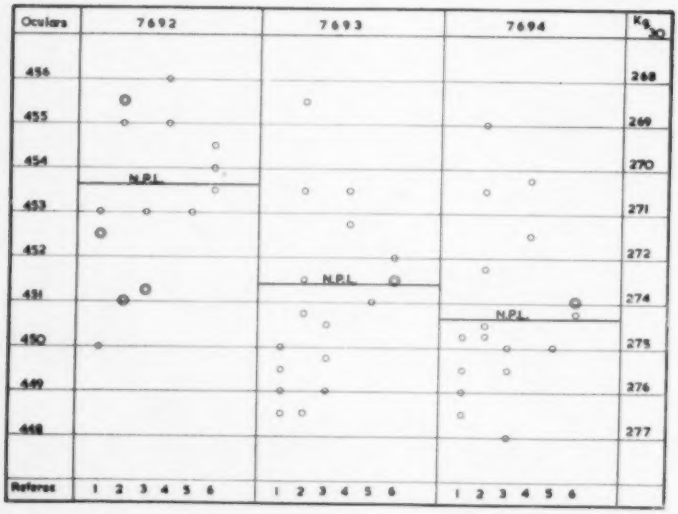


Fig. 2

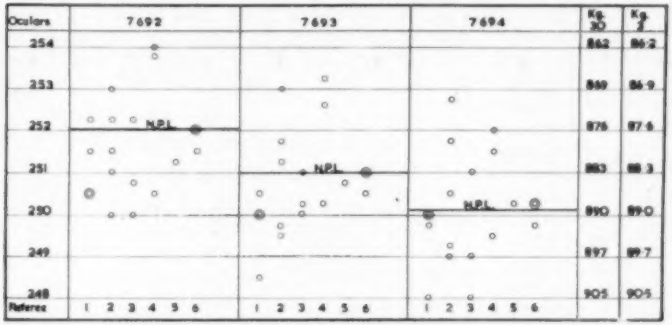
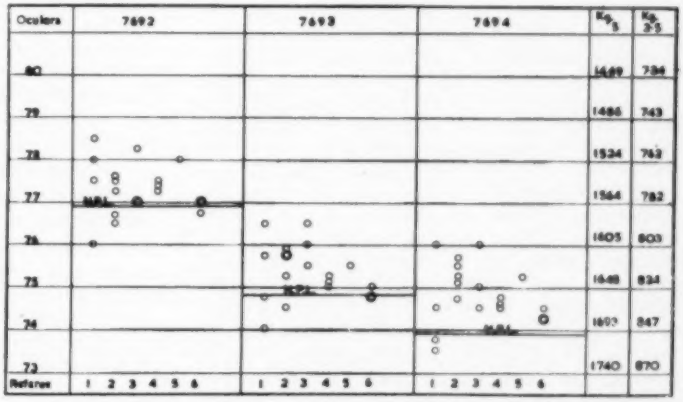


Fig. 3 (left)

Fig. 4 (below)

spond to a hardness of 890 HV and with a 3 kg. load to a hardness of 89 HV. In the case of a load of 30 kg. this range becomes serious as it corresponds to approximately 25 HV units.

In the case of the smallest impressions, Laboratory No. 1 reported the highest average range, *i.e.*, 2.5μ. This is very serious. The size of the impressions was approximately 75μ and assuming a load of 2.5 kg. this corresponds to a hardness of 824 HV and a range of 2.5μ corresponds to approximately 56 HV units. If, however, the load had been say 5 kg. then 75μ corresponds to 1,648 HV and the range would have been 112 HV units.



The general conclusions of the committee are well expressed in the comments from the National Physical Laboratory, which are quoted in full in Appendix 1.

A statistician's report upon the readings forms Appendix No. 2.

APPENDIX No. 1

Comments from the National Physical Laboratory

Reproducibility of hardness values in the Vickers scale of hardness is dependent on :—

(a) The homogeneity of the test specimen ;

(*b*) The ability of indenting machines to make indentations of identical size in material of the same hardness ;

(*c*) The ability of different observers, using different microscopes, to agree upon the size of an indentation.

The errors arising from each of these sources are additive and are of two distinct types, *viz.*, systematic and random. For example, if, of two indenting machines, one has an incorrect load then this machine will produce indentations which are consistently different in size from those of the other machine and hardness values obtained from this machine will have a constant or systematic error. In addition, each machine will produce indentations of slightly varying size, even in material of the same hardness, due to small variations in the loading conditions for each indentation. These small variations give rise to random errors in the hardness values obtained. It is the responsibility of designers and manufacturers of indenting machines to ensure that these systematic and random errors are negligible.

Turning now to the measurement of indentations it will be seen that there are two sources of systematic error. The first is due to the measuring microscope which as a result of incorrect calibration or of some peculiarity of the illuminating system, will give values consistently different from those obtained with another microscope. The second source of systematic error is due to the observer who, with any particular measuring miscroscope, will obtain consistently different values from a hypothetical average observer. In addition to these systematic errors, there are random errors

of measurement due, mainly, to the inability of even an experienced observer to repeat precisely the settings he makes on the corners of the diagonals. The two sources of systematic error give rise to a constant error of measurement for any particular measuring microscope and observer, whereas the random errors fluctuate from one indentation to the next and may be eliminated if the mean value of a sufficiently large number of indentations is considered.

To improve the reproducibility of hardness values in the Vickers scale it is necessary to reduce random errors of measurement to a minimum, otherwise no hardness value is reliable unless it is the mean of a very large number of indentations. In addition it is necessary either to reduce the systematic errors or, for any particular measuring microscope and observer, to assess the magnitude of the systematic errors and make appropriate corrections. As a contribution to the solution of this problem, the National Physical Laboratory is building a measuring microscope and providing a group of observers so that any one observer, measuring a group of 10 indentations, can repeat his own value, or the value of any other member of the group, within close limits. Although work on the final measuring microscope has not yet been completed, experience over several years with a prototype instrument has shown that the Laboratory can, at present, maintain a level of reading for 10 indentations within 0.5μ and it is gratifying to note from the draft report of the ISME hardness subcommittee that one referee laboratory, No. 6, not only obtained a mean value for the nine indentations within 0.1 μm of the value obtained by the NPL but also agreed with each NPL value to within 0.5μm.

To assess completely the performance of a measuring microscope and observer it is necessary to determine the magnitude of the two systematic errors mentioned above and also to measure the dispersion of the random errors. The latter can then be used to determine whether the systematic errors disclosed are significant. It will be appreciated that it would be incorrect to condemn a microscope or an observer for failing to agree with a second miscroscope and observer by, say 2μm, if it were subsequently discovered that neither observer could repeat his own values within 2μm. It is, therefore, unfortunate that in the results obtained from the referee laboratories no observer has measured the indentations more than once on any one machine and in consequence it is impossible to obtain a reliable estimate of the random errors. However, the results do show that if only one type of measuring microscope is considered, *i.e.*, the Vickers microscope, then the differences between the referee laboratories are not significant in comparison with the variations within the laboratories. This implies that a great deal of the variability arises from systematic differences between the observers and work should be directed to disclosing the cause of these differences and eliminating them.

APPENDIX No. 2

Statistical Analysis of Table II

Analyses have been made of the readings made by the six Referee Laboratories of hardness of three specimens. Each specimen contained a small, medium sized, and large impression.

Estimation of Error of Measurements

An analysis is first made of the variation between operators within their laboratories. In the case of Laboratory 2, it is assumed that the readings were made by five different operators.

The variation within a laboratory for each size group of specimens can be classified into three components :—

(i) Due to specimens ;
(ii) Due to operators ;
(iii) Random error.

The random error component consists of that variation which remains unaccountable after removing from the total variation of observations within a laboratory, the variation of specimen averages and variation of operator averages.

This random error is measured by the Standard Deviation.

The standard deviation can be interpreted as follows : If an operator makes observations continuously on an impression 68 per cent of his observations will lie within plus or minus one standard deviation from the average level. Ninety-five per cent of his observations will lie within plus or minus two standard deviations from the average level.

Details of how the standard deviation is obtained after removal of components due to operators and specimens are given later in this Appendix.

In Table I are tabulated the estimates of error, referred to as Standard Deviations obtained for each laboratory for the three sizes of specimens.

TABLE I—*Standard Deviations for Laboratories*

Laboratory	Specimen size		
	Small	Medium	Large
1	0.50	0.54	0.62
2	0.30	0.37	1.11
3	0.24	0.51	0.42
4	0.05	0.45	0.66
6	0.10	0	0.30

Comments

1. The readings on the small samples have been made much more precisely by Laboratories 4 and 6.

2. The medium sample was read with no random error by Laboratory 6, that is after accounting for differences among the three specimens and operators, there was no residual error remaining. From this we might infer that either this laboratory was able to read with extreme accuracy, or that the operators made a set of observations and have presented as their readings the average of these sets of observations. It should be noted that the standard deviation of the mean of independent observations is equivalent to the standard deviation of an individual observation divided by the square root of the number of observations.

3. In general the precision in oculars of reading the large samples is lower than for the two smaller sets of samples.

Differences Among Operators Within Laboratories

The standard deviations in Table I enable us to state how precisely operators have measured and whether the differences between their average levels can be attributed to chance or are indicative of real differences in reading levels.

The range of operator mean within laboratories and the range of operators' readings that we would not expect to be exceeded if there were no systematic differences among operators are given in Table II.

TABLE II—*Range of Operator Means and 99 per cent Limit*

Laboratory	Small specimen		Medium specimen		Large specimen	
	Range of means	Range *	Range of means	Range *	Range of means	Range *
1	2.5	1.6	1.7	1.7	2.9	2.0
2	1.1	0.9	3.3	1.1	5.4	3.3
3	1.2	0.9	2.1	2.0	1.7	1.6
4	0.3	0.2	2.8	1.7	0.1	2.7
6	0.1	0.4	0.5	0	0.4	1.2

*Interpretation of Range**

Given that operators are liable to random errors only in their observations, we would not expect them to return the same readings exactly. The difference that would not be expected to occur by chance more than one in a hundred is calculated. If the actual range exceeds this level we conclude that besides the residual error of measurement, that there are in fact systematic differences among operators. The case of Laboratory 1 for the small sample is described later in this Appendix.

It is seen in Table II that Range* is exceeded for each specimen size in Laboratories 1, 2 and 3. In these laboratories there are obviously systematic differences amongst operators.

In general the results of operators within Laboratories 4 and 6 were very reproducible and significant differences do not exist in general amongst operators. The range in these two laboratories only once exceeds half an ocular.

Difference Among Laboratories

Table III shows the means for each laboratory.

TABLE III—*Laboratory Means*

Laboratory	Specimen		
	Small	Medium	Large
1	75.7	250.1	450.2
2	75.9	251.1	452.6
3	76.2	250.3	450.3
4	75.9	251.9	454.0
5	75.3	250.8	451.3
6	75.2	250.9	452.2
N.P.L... ..	75.2	251.1	451.9
Range	1.0	1.8	3.7

The increase in the number of observations compared with Table II produces greater stability of ranges.

Laboratories as a whole are not considered as indicative of variation of hardness as readings by operators as a whole. These differences are discussed in the next section.

Differences Among Operators

Table IV shows the two extreme means for operators over the three readings on each group of impressions.

TABLE IV—*Extreme Operator Readings*

Ranking	Specimen		
	Small	Medium	Large
Highest reading ..	77.0	252.9	455.3
Next highest ..	76.9	252.8	452.3
Mean	75.8	250.9	451.7
Next to lowest ..	75.3	249.3	449.5
Lowest reading ..	74.5	249.0	449.0
Range	2.5	3.9	6.3
Range**	1.1	1.4	1.7

Note.—Range ** is the range that we would not expect to be exceeded by chance more than one time in a hundred.

The range in operator means is much larger than would be expected by chance. It should be noted that the differences amongst operators includes differences among hardness testing machines.

General Comments

Although an individual operator's observations are fairly reproducible about his own particular level (Table I refers), Table IV shows that his

readings may differ considerably from the true hardness of a specimen. In fact, given that the hardness of a specimen as found by a randomly chosen operator was X oculars, we could say with reasonable certainty, that the Range X − 2 oculars and X + 2 oculars will include the true hardness value.

Estimation of Residual Error

Consider the observations of Laboratory 1 on the small specimen. The original observations were :—

TABLE A

	Sample 7692	Sample 7693	Sample 7694
Operator 1	78.5	76.5	76
Operator 2	77.5	75.8	73.8
Operator 3	76	74	73.5
Operator 4	78	74.8	74.5

For ease of presentation, the above data are multiplied by 10, and 730 subtracted to obtain :—

TABLE B

	Sample 7692	Sample 7693	Sample 7694	Mean
0.1	55	35	30	40
0.2	45	28	8	27
0.3	30	10	5	15
0.4	50	18	15	27.7
Mean	45	22.8	14.5	27.4

The operator variation is given by the differences among the operator means. The difference in Sample means is given by the difference amongst the Sample means.

The operator and sample variability can be eliminated from Table B by subtracting from each observation, the relevant Operator and Sample means. The overall mean is added, so that the resulting values are the discrepancies from zero.

TABLE C—*Residuals*

Operator	Specimen		
	7692	7693	7694
1 ..	− 2.6	− 0.3	2.9
2 ..	0.5	5.6	− 6.1
3 ..	− 2.6	− 0.3	2.9
4 ..	4.7	− 5.0	0.3

These results are squared and the sum of the squares divided by the number of independent observations (in this case, six). The square root of this gives an estimate of the Standard Deviation.

In this case the Standard Deviation is found to be 5.0.

If there were no significant differences among the operators, the variation of the operator means would be less than the random variation. This is because the mean of a set of random observations varies less than the individual observations, *i.e.*,

$$\text{Standard deviation of Mean of N observations} = \frac{\text{Standard Deviation of Individual Observations}}{\sqrt{N}}$$

In fact, the Standard Deviation of operator means is so great that it would be unlikely to have arisen by chance. We, therefore, conclude that there are significant differences among operators in Laboratory 1.

The means are :—

Op. 1 = 77.0
Op. 2 = 75.7
Op. 3 = 74.5
Op. 4 = 75.7

There is a range of 2.5 oculars. The Standard Deviation of individual operators' observations suggests that the range of the four operators' means to be expected if the operators read at same level (which they do not) would be

$$\frac{0.5 \times 2.06}{1.73} = 0.6 \text{ oculars.}$$

Note.—The range is used frequently as an easily calculable estimate of the Standard Deviation.

APPENDIX 3

One member of the Committee dissented from the findings of the Committee, and his comments are given below :—

Conclusion 1

This apparently gives an immediate, but quite erroneous, overall condemnation of hardness testing by any system employing an applied load and diagonal measurement.

Conclusion 2

The citation of a case where industrial users showed a greater degree of agreement than the referee laboratories appears to be based on the measurement of a small impression in Series 1 by referee laboratory 1 on Specimen No. 18 only. The following figures refer—

Test Piece	Deviation of Lab. 1 results from Lab. 5
2	0—4
4	0—2
5	1—3½
7	0—2
8	½—2
11	0—1
14	2—4
15	1—1½
16	0—1
17	½—1
18	7—12
20	½—1
21	2—2½

If this is the case, over emphasis is being placed on a figure which by common sense interpretation may well be a simple mistake.

Conclusion 3

Even if Conclusion 4 (p. 173) is accepted, then its application relative to a 10 kg. load on the specimen of 752 HV results in an uncertainty within the range 739/767. This hardly merits the elimination of diamond pyramid indentation tests on such materials.

Generally, the series has revealed that even in critical testing serious errors do occur, but in my view the correct course to take is to implement the suggestion given by the NPL in the last sentence of their comments (Appendix 1) with which I am in complete agreement.

Members of the Group Committee responsible for this investigation are:—

J. F. Kayser (Gillette Razors and Blades), Chairman; A. C. Tingle (Gillette Razors and Blades), Hon. Sec.; H. G. Harper (Vickers-Armstrongs (Engineers) Ltd.), V. L. James (Enfield Technical College), W. W. Kee (Enfield Rolling Mills (Aluminium) Ltd.), C. J. Thwaites (Tin Research Institute), F. J. Tranter (Ministry of Supply, Metallurgical Dept., A.I.D. Laboratories), T. G. Woodward (Jos. Lucas (Electrical) Ltd.), J. Woolman (Brown Firth Research Laboratories).

DISCUSSION

Dr. E. MARKS (Richard Thomas and Baldwins Ltd.) suggested that the conclusions in the paper were much too sweeping. It was common ground that nothing could be measured exactly, but the paper suggested that hardness testing by this method was far more inaccurate than other measurements, and he did not think this was so. The difference which Mr. Kayser had suggested between measuring hard and soft materials was in fact a difference arising from measuring very thin products. An ocular impression of 200μ on hard material was just as accurate as a similar reading on soft material.

Mr. J. F. KAYSER replied that it was extremely difficult to measure the length of the diagonal of a diamond impression ; indeed, he was not sure that the problem had been solved.

He agreed that an impression of 200μ on hard material could be measured with the same accuracy as a similar impression on soft material, but the significance of a range of say, 10μ was not the same in both cases. Assuming a load of 20 kg., 200μ corresponded to 927 HV and in that region a range of 10μ corresponded to a range of 92 HV units, but a generally accepted specification in this region called for a range of 40 HV units. If one assumed a load of 2½ kg. a reading of 200μ corresponded to 116 HV units and then a range of 10μ corresponded to a range of only 12 HV units which was usually acceptable.

Mr. KAYSER agreed that the difficulties increased with decrease in thickness and that was referred to in conclusion No. 3 in the report.

Dr. MARKS commented that in determining the accuracy of measurements it was necessary to quote percentages.

Mr. KAYSER replied that to quote percentages in a specification might be misleading. To take an example, the chromium content of razor-blade steel was acceptable between the limits of 0.15 per cent and 0.25 per cent, but in the case of an 18 per cent chromium steel limits of 15 per cent to 25 per cent would be ridiculously wide and unacceptable.

Mr. P. M. COOK (J. J. Habershon and Sons Ltd.) said that they were discussing a percentage difference which was the same at different hardness levels. Unfortunately, the strip user normally gave a hardness range within which to work, and that range determined whether the material was hard or soft. He supported and welcomed the Committee's views because firms were constantly in trouble trying to agree with customers upon a hardness figure. On occasion, his company even received back rejected coils and chopped pieces off them to prove that they were, in fact, within the specified range by doing a test on two different machines with different operators. Arguments often arose over 10 to 20 points because an attempt was being made to work to specifications in the lower hardness range of 235 to 255 Vickers hardness on carbon steel. The conclusion of the paper suggested that to be asked to work to a 20 point range at about 250 was stretching things a little too far.

He would welcome Mr. Kayser's comments on what was to be done in the future about the testing of very thin strip. He quoted an example in which his company had produced shim steel 0.003 in. thick and had been asked to work to a specification of 120 to 160 Vickers.

Referring to the Vickers charts of accepted load at different hardness values, he said that such a test could not be done on the standard Vickers machine. Yet it was necessary to try to produce material to these hardness figures. He could give examples in which material had been rejected on a hardness test when, in fact, such a hardness test had been impossible to carry out. What comments had Mr. Kayser to make on this type of problem, which confronted them all the time ?

Mr. KAYSER replied that Mr. Cook had given a fair resumé of the facts and he (Mr. Kayser) did not know the solution. Internally there was no objection to using a hardness test on the product of a rolling mill but it was necessary to work in the

(*Continued in page* 202)

DRAWING CUPS FROM THIN METAL SHEETS

Using Rubber Pads

By L. WALTER

A METHOD is in use in Germany for drawing cups from thin metal sheets by means of rubber pads. This method, although neither revolutionary nor deviating from conventional drawing technique may have advantages under certain conditions. The design of the cup, the thickness of the sheet, and qualities of sheet material have to be suitable. The saving of a die may well pay for certain alterations required in tooling.

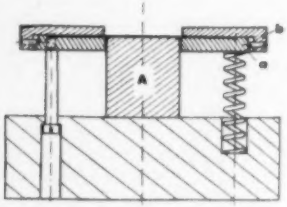
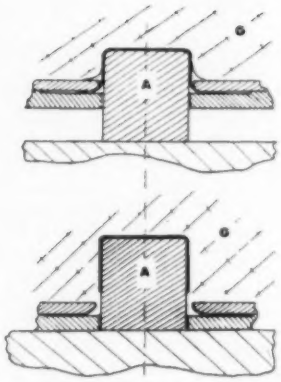


Fig. 1



Figs. 2 *and* 3

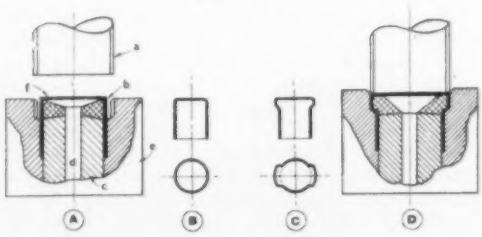
When blanking, punching, and bending sheets with rubber pads, the tools can be simplified as only one punch is required instead of the usual die and punch arrangement. For the drawing of cups from sheet blanks, one bottom punch will do, a rubber pad acting as upper die. Unfortunately in the case of hollow parts wrinkles or folds are, as a rule, unavoidable. This can be remedied by using the simple device shown in Fig. 1. A circular plate (*a*) is placed round the fixed punch and braced against the base plate by springs. It fits the punch closely, its outside diameter being somewhat larger than that of the sheet blank, which is accommodated in a recess for centering. A cover plate (*b*) with a chamfered inside edge is placed over plate (2) to which it is fixed by four pegs.

Figs. 2 and 3 show the drawing process. The rubber pad is pressed over the punch and the sheet is pulled out from between plates (*a*) and (*b*). Since both plates fit the punch mandrel closely, no folds or wrinkles can form. The Shore hardness of the rubber should be 50 to 60 for sheets of medium hardness and from 30 to 40 for soft sheets.

Cups or other thin-walled parts can easily be bulged with rubber pads. Figs. 4 and 5 show a

(*Continued in page* 213)

Figs. 4 *and* 5



GRAIN-SIZE—

Its Measurement and Significance in Relation to Cold Rolling

By V. L. JAMES, A.I.M., C.G.I.A.*

A paper presented at the Annual Conference of the Institute of Sheet Metal Engineering, London, November 11 and 12, 1959.

Introduction

IN single-phase metals the mechanical properties and to some extent the physical properties, *i.e.*, magnetic, electrical, are dependent on grain-size as well as crystal orientation (Fig. 1). Purity of a material can also affect properties, the impurity atoms acting either as obstacles to the movement of atoms along planes of easy glide, or by modifying crystal structure. The amount and distribution of the second phase will influence the extent to which the properties are altered.

The bulk of sheet-metal fabrication, particularly where severe deformations are involved, is done with single-phase materials. Minor amounts of second phase can sometimes be tolerated if deformation schedules are not complex. The present paper will be confined to materials with substantially single-phase structures. It is not proposed to examine the influence of the size of a second phase on the structure or the properties of metals.

Often showing considerable ductility a metallic single crystal is weak, offering a low resistance to deformation. A polycrystalline aggregate of the same material is very much stronger and at the same time retains a relatively high proportion of the ductility of the individual crystals, and as crystal size decreases, strength properties of most materials increase. Hardness, grain-size curves have been published by several people for copper, iron, nickel, and their alloys. Sets of results indicating relationship between ultimate tensile strength, yield stress, and grain-size are available. The relation between ductility and grain-size does not appear to have received quite the same attention. In most cases the strength properties follow the form of curve shown in Fig. 2.

Grain-size and Specifications

The "texture" of a drawn surface depends on grain-size. Coarse grain gives a rough surface or "orange-peel" effect. This has been ascribed by several people to the movement of blocks of atoms within the crystal squeezing through to the surface and buckling of the crystal surface faces. An elaboration of this is thought necessary, when it is considered that severe surface roughness is clearly discernible by touch in deformed sheet material with a grain-size of 0.065 mm. average diameter, *i.e.*, approx. 20 grains per mm. Thickness also influences the degree of roughness experienced, a thin material being often rougher than a thicker one with similar crystal size.

There can be no doubt about the importance of the influence of crystal size on the formability of sheet and strip metals. This is realized by most people who draw up specifications for annealed stock that might be used for forming. American, German and Swedish standards call for grain-size control in most specifications for soft materials. British Standard Specifications while acknowledging that structures should not be coarse do not specify

* Enfield Technical College.

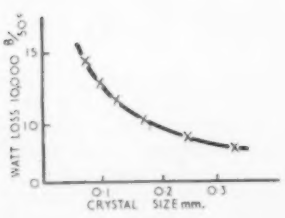


Fig. 1 (left).—Relation between magnetic loss and crystal size in 4-per cent Si. transformer steel. (Jay, A., J. Sc. Inst., 1941, 18, p. 81 (Taylor))

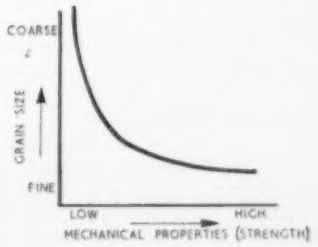


Fig. 2 (right).—Trend of mechanical properties with variation in grain-size

numerical grain-size limits. Control by B.S.S. is limited to examination of the exterior surface of a bend test and assessing its roughness. Individual firms are sometimes more conscious of the fact that crystal size can be given some form of number. Private specifications often include some reference to grain-size, and this value is frequently copied from one specification to another without attempting to relate material requirements to the job being produced. The grain-size value is often quoted as a single number, the producer being left to interpret the range, if any, that may be acceptable. At the other end of the scale there are the people who give due care and attention to specification requirements, at the same time being mindful of the producer's difficulties. One manufacturer to the author's knowledge, who is very specification minded, issues an internal specification suggesting how grain-size should be estimated.

In a large number of cases it is left to the producer to examine a sample of the component to be produced, draw up a tentative specification, and supply material to this. Examination of one component can, and often does, allow misinterpretation of properties required. Diplomatic liaison between technical personnel of the consumer and producer should enable good quality material to be produced and supplied. This is, of course, not only restricted to structure of materials.

Crystal Form

If a section were to be cut through a box packed with regular shaped solids of uniform volumes the plane of section would show a series of irregular non-uniform areas. The range of sizes and shapes obviously depends on the original shape. If these were spheres, then areas seen would consist of circles whose diameter varied from just visible to that of the spheres. If the original volume was composed of cubes, packed in an irregular manner, the plane section would show a variety of shapes from triangles to parallelograms, the maximum area being greater than the face area of the cube. In the first case it would not be difficult to judge that spheres were the initial shape and to assess regularity and size by a simple analysis. To judge the form and regularity of the second set would require a reasonable level of critical appreciation and a detailed analysis.

When considering an aggregate of crystals in a polycrystalline specimen it is not possible to think in terms of :—

(*a*) Simple shapes, nor

(*b*) Regularity of the existing shape.

The production of equiaxed crystals is the aim (or should be) of the sheet-metal fabricator. Neither the metallurgist nor the manufacturer have much control over the shape of the equiaxed crystals that cohere to form annealed sheet and strip material.

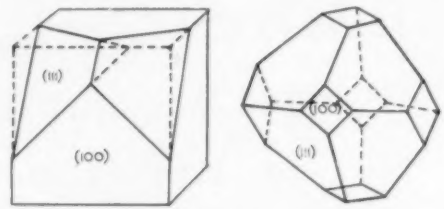


Fig. 3.—Fourteen-face solid figure (tetrakaidekahedron). The (100) and (111) planes are indicated in the appropriate positions

The probable shape of crystals has been studied by a few workers, their work and suppositions being accepted by the great majority of technical people concerned with metallic crystal structures. For metals with cubic structures it is difficult to find valid arguments against the acceptance. The most probable shape of crystal in a random equiaxed polycrystalline mass is the tetrakaidekahedron, the technical term for a 14-face solid figure (Fig. 3). This is certainly feasible from observations of many microstructures. The figure repeated can completely fill a given space, and is outlined by the (100) and (111) of the cube structure. Regularity is another matter ; it is here that the skill of the technician in devising suitable economic working and annealing schedules is very important. Regularity of structure is a most important factor, from two viewpoints : (1) properties and formability of material ; and (2) ease with which crystal size can be correctly evaluated.

Grain-size Estimation (General)

Grain-sizes may be measured by :—

(1) X-ray diffraction techniques, or

(2) Visual methods

(*a*) examination of a deformed surface or fracture ;

(*b*) examination of metallographic surface.

X-ray methods require specialized equipment not normally found in a general routine laboratory, and also the services of a competent X-ray physicist. The diffraction technique is used for the estimation of crystal sizes of the order of 10^{-3} to 10^{-4} cm. Crystals of this size would be better referred to as crystallites. Crystal sizes of this magnitude are seldom if ever encountered in soft stock used for pressing and drawing.

Visual techniques such as examination of worked or fractured surfaces are in universal use. Estimation of grain-size from fracture tests is restricted to cast metals and certain classes of heat-treated steels. This is not relevant to the present paper.

Assessment of crystal size from the appearance of the surface of a deformed test specimen is a con-

venient shop floor test. It is widely used by press-shop personnel as a guide to the suitability of a piece of sheet for pressing. The test should not be despised by the qualified laboratory metallurgist; experience of press conditions, knowledge of test techniques (the metallurgist should do a test himself!) and a critical approach to surface examination can give a wealth of information about the material. The disadvantage is, of course, that phrases such as "relatively smooth" and "slightly rough" can describe the same surface appearance to two groups of operators. A standard scale of values is essential in this case, such as indicated by Field and Salter(1), who describe a simple method of grain-size estimation used by the British Aluminium Co. Arbitrary numbers are given to certain grades of roughness of an Erichsen dome.

No.	1	2	3	4	5	6	7	8
Grains per mm.^{2}	250	300	400	550	800	1,200	1,750	2,700

It was indicated that standard samples were used for checking, but that experienced operators rarely referred to standards.

It would not be practicable to use one of the modern surface roughness instruments to set a standard.

The surface of a prepared metallographic specimen provides a basis from which numerical values of grain-size may be determined. Examination and measurement can be conducted with or without the aid of a microscope depending on the size of the crystals. Limitation of the method is the ability to see and resolve the smallest area of crystal section. With an optical unit of the type normally found in a routine works laboratory, crystal sizes of the order of 0.005 mm. (5μ) can easily be seen and assessed. Sizes of this order lie well within the ranges normally encountered in sheet and strip materials, *i.e.*, 10μ is generally considered fine.

Before considering in detail methods of measuring it is advisable to consider what is meant by "crystal" or "grain."

The micro-section of a suitably prepared surface of metal may appear as a series of irregular areas separated by thin lines—grain boundaries (straight dark bands across the cells or crystals of face-centred cubic metals being ignored for the present). This indicates the actual crystals. In single-phase metals such as iron and aluminium, the crystal areas may be subdivided into smaller areas, again separated by a thin irregular boundary. This boundary is not so distinct, and is often only revealed by a definite sequence of straining and annealing. This latter structure is known variously as veining, substructure, cell structure, polygonized structure. For practical purposes this fine structure has no influence on cold deformation characteristics, although it is important when considering creep properties.

In materials that show pronounced directionality, crystal size appears coarse. This is due to the bulk of small crystals having only slight orientation differences, and acting in an aggregate as a large grain. The boundaries of the small crystals are difficult to develop in the microsection, because of their low energy state. This special case of directional material will be discussed later. For general crystal-size estimation, the grains that are outlined by clearly defined boundaries only, will be considered. The boundaries should be clearly and quickly outlined by standard metallographic methods.

Methods of Measurement

Grain-size can be reported as :—

(1) Average grain diameter or area;

(2) Number of grains per unit area;

(3) Number of grains per unit volume—spatial grain size.

(4) Leading grain-size classification (JKM);

(5) Sieve or mesh number.

All these methods of reporting crystal size have been used in technical reports and papers, except perhaps the last one. This is unfortunate as comparisons between sets of results is made arduous by trying to convert from one system to another. Conversion of results from one scale to another, however carefully made, is generally unsatisfactory; for example, hardness grain-size curves (Fig. 4). Critical comparison requires recalibration of the ordinate.

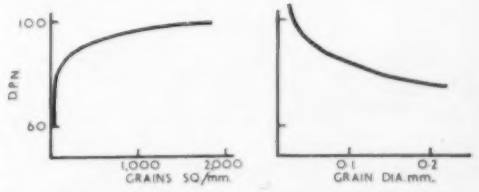


Fig. 4.—Grain-size against hardness for 70/30 brass plotted on different grain-size scales

The basic procedures for grain-size determination are :—

(1) Photographing representative sections and measuring the areas of crystal sections.

(2) Counting number of grains on the screen of a projection microscope :—

(*a*) included in a given circular area (Jeffries);

(*b*) those cut by lines of definite length (Heyn's intercept);

(3) Comparison of structures with standard charts or prints : or comparison of structure with an ideal network in an eyepiece graticule.

From these procedures crystal size can be reported by one or more of the methods listed above. Procedures 1 and 2 are very tedious and time-consuming. The comparison technique can be very rapid, and is the method generally used for copper and copper-base alloys. Charts have been prepared by A.S.T.M. covering the classifications :

(*a*) Untwinned—flat etch ;
(*b*) Twinned—flat etch ;
(*c*) Twinned—contrast etch ;
(*d*) Austenite grain.

It has been suggested that one standard E.112–58T be offered for universal metallurgical application for grain-size measurement. This would eliminate the existing separate standards for each metal and alloy.

The sieve and mesh number is unusual and is suggested as a technique that would be useful in helping to visualize size and shape of crystals in three dimensions. The technique involves conditioning of the sheet metal such that clean and quick disintegration into component grains would take place, when treated with a suitable corrosive media. The resulting powder could then be classified. The disadvantage is that not all materials can be easily disintegrated, particularly when they exist in the annealed state. Copper-zinc alloys can be treated with ammonia, or mercury, but some degree of stress is required. Removal of the mercury film also presents a problem.

Fig. 5.—Disintegrated stainless steel (E.N. 58c) showing individual crystals. (.1 C. 10 Ni. 18 Cr.). × 25

[Courtesy of Mr. J. F. Kayser]

Austenitic stainless steels are relatively easy to disentegrate by slow cooling from 700° C. over 5–6 hours, and treating in boiling copper-sulphate sulphuric-acid solution. This treatment is not high enough to modify the as-received grain-size of an anealed sheet. Crystals obtained are sharp faceted and clean ; in fact, planes of annealing twins can often be seen (Fig. 5)*. Loss in weight during disintegration is of the order of 0.5 gm. on 100 gm. original material. Crystals from the disintegrated material can now be subjected to sieve analysis and a clearer picture of regularity obtained. The method is not quick and would not be suitable for routine control work on grain-size. It is suggested that it has a clear application in the establishment of a standard grain-size.

The leading grain-size is obtained by using the JKM classification, developed in Sweden. Here there is a geometric series ratio factor of 2, defining the section areas of the crystals.

JKM No.	0	1	2	3	4	5	—	10
Area of crystal section μ^2	1	2	4	8	16	32	—	1,024

A photograph of a representative section is made and section areas measured. The number of grains in a given class number is then plotted against the classification number. A definite peak is developed with normal structures, the grain-size represented by this peak being termed the leading grain-size. It is of interest to observe that the leading grain-size comes nearer to the size of larger grains than does average grain size. This value is important and useful, since the smaller areas are given due consideration along with the larger areas. The method is somewhat lengthy and not recommended for routine work. It can be very useful for investigation work, and standardization purposes. A set of charts showing microstructures for each classification has been made ; this enables a comparison of unknown structures to be made. This expedient would be considered more useful if each laboratory prepared their own primary charts. It is felt that the value of this method lies in the analysis of the ranges of areas observed.

Counting of grains or crystals in a given projected area offers a moderately quick method of grain-size assessment. There are two main procedures, first that devised by Z. Jeffries, often

* This illustration is an amended version of that in the original paper.

referred to as planimetric procedure(2). An area of convenient size—50 sq. cm. is usually quoted—is scribed on the projected image of the microstructure.

Sizes to give 50 sq. cm. (5,000 sq. mm.).

Circle 79.8 cm. dia. Square 70.7 by 70.7 cm.

Rectangles 65 by 77 mm.
60 ,, 83.3 ,,
55 ,, 91 ,,
50 ,, 100 ,,

A ground-glass screen offers a convenient table to work on. Counts can be made rapidly, each grain being checked off by a small mark, using an indicator that can be erased later without difficulty. Ink spots have been found convenient and easy to see.

The number of grains included in the area plus half the number intersected by the boundary line is taken as a measure of the number of whole grains. A multiplier factor f (Jeffries multiplier) converts the value to grains per sq. mm. In his work on grain-size of aluminium, Phillips used a $2\frac{1}{2}$-in. dia. circle, a magnification of $63\frac{1}{2}$ and a factor 0.6 for circumference grains.

Magnification of the structure has to be selected to suit the crystal size of the material. It is suggested that counts should include at least 100 grains, since this is said to be the lowest level that may be considered statistically equivalent. Higher orders of accuracy should include 800 to 1,000 grains, and counts should never be made on less than 50 grains. The main difficulty with the higher number counts is the uncertainty of seeing which of the small areas constitutes a grain particularly with twinned structures. Counts of 5 areas of 100 to 125 grains are considered to give reasonable estimates related to the time involved.

When crystals are not considered equiaxed, the above procedure may be carried out on specimen surfaces representing three mutually perpendicular faces. A value for number of grains per unit volume can be obtained :

$$\text{grains per unit volume} = 0.7\, n_A \times n_B \times n_C$$

where n = grains per sq. mm. on three perpendicular faces, A.B.C. Grain shape is assessed from the ratios

$$\frac{n_A}{n_B} : \frac{n_B}{n_C}$$

This procedure is not considered as satisfactory as the intercept method. It is difficult to visualize the shape of the grains, with the numerical factor on any surface, particularly if grains are only slightly elongated. Heyn's intercept method is considered more convenient and practical. This technique involves a count of grains that intercept lines of convenient length. The counts may be made along normal, longitudinal or transverse directions on the specimen. The length of line should be such that the number of grains intersected is approximately 20 to 30. Phillips used a line 15 cm. long with a magnification of × 150.

A modification of this technique is to traverse the stage and specimen, counting the number of grains that pass a reference line. This has the advantage that a projection screen is not essential, and that magnification can be adjusted to give reasonable grain-size. Reproducibility of this is claimed at 2 per cent. Where grains are equiaxed then very little difference would be shown between counts made in longitudinal and transverse directions. It was observed on some work on grain growth in 70/30 brass that there was a curious tendency for grains to appear a few per cent short in longitudinal direction (7) (referred to rolled sheet). The material was judged to be normally non-directional.

Where grains are not equiaxed, or when examining lightly worked specimens, the degree of elongation can be related to the intercept number. The visual appearance of the structure can provide an immediate check on values reported. The intercept numbers can be multiplied together and grains per unit area or volume can be calculated.

$$\text{gn. per cu. mm.} = 0.7 \sqrt{N_A \times N_B \times N_C}$$

where N = Intercept No.

When grains appear flat or pancake shaped a factor of 1.0 is suggested instead of 0.7. Both Jeffries and Heyn methods are specified for reference work, the latter being used in the case of non-equiaxed grains.

The most common routine method for grain-size evaluation is by comparison. The structure under consideration is compared with charts of microstructures of similar forms, comparisons being made by viewing the specimen direct using a standard bench microscope, or by projecting the image on to a screen. The charts are placed in a convenient position beside the microscope or screen. Transparencies of the structures may be used in place of prints and in this case the refinement of a split viewing screen is a distinct advantage. Comparing photographs in a room dimmed to permit screen viewing can be tiring as well as difficult. Increasing overall room brightness reduces contrast, both on the screen and though an eyepiece, and using back lit transparencies considerably reduces eyestrain. The structures should be examined at the same magnification as that of the standard charts, magnifications of × 100 being generally used except for copper-base alloy structures, where × 75 has always been favoured. A.S.T.M. provide for examinations to be made at other magnifications and a conversion table is given in the appropriate standard. If it is desired to examine fine structures at higher magnifications in an attempt to gain greater accuracy, standard charts at the higher magnification should be prepared and used.

A modification of the comparison method has been described by Hull[3]. He suggests that a suitable eyepiece and objective be chosen, and camera length adjusted until image of unknown has same number of grains per unit area as a standard network structure. The grain-size is read from a graph previously calibrated from known samples. A high degree of accuracy and speed are claimed for this method.

TABLE I—*Relative Speeds and Accuracies*

Method	Time/ estimation	Probable error in Grain-size units
A.S.T.M. E19.39T ..	½	0.4
Intercept on 5 in. ..	½	0.38
Comparison (Hull) ..	1	0.15
Jeffries	10 to 15	0.05
Spatial count ..	60 to 100	0.05

The identification of grains and/or boundaries is a common accuracy factor for all methods.

Reporting of Grain-size Values

There does not appear to be any recognized uniform way of reporting grain-size in this country. The general tendency is for iron and steel workers to quote grains per sq. mm., most non-ferrous alloys as average grain diameter mm., and aluminium alloys as grains per sq. mm. or average grain diameter, sometimes with an attempt at reporting L/T ratios as an indication of shapes. The American specification does not lay down any specific way of quoting grain-size but it is tentatively suggested that A.S.T.M. grain number N should always be included in the report.

$$\text{A.S.T.M. gr. size number N} = \frac{\log n_1}{0.3} + 1$$

where n_1 = grains per sq. in. at $\times$ 100 (or $\times$ 1).

There does not seem to be any point in masking the grain-size value with a letter or another number. A figure quoting average grain diameter in microns would be quite adequate for all work.

Comparison of Methods

It has been shown that there is a considerable difference in time factor between the general methods (Table I). Analysis by the disintegration and sieve methods requires a minimum time of 24 hours. This completely rules the method out for routine control work. While the method does allow detailed examination of actual grain-size and shape it is envisaged that some difficulty would be experienced in obtaining general agreement on the method of sieve analysis. The powder metallurgist could no doubt be co-opted in this direction. There would also be some question as to completeness of disintegration into component crystals, as well as possibility of reduction in crystal size by solvent action of the corrosive media. Microexamination of several individual crystals of stainless steel after disintegration as described showed that all smaller crystals appear as single units. Very large ones often consisted of two or three units, but the boundaries are obvious, and it is easy to detect multiple units under low power examination. Choosing conditions such that weakness to the corrosive media is severely localized to grain boundary no difficulty is likely to be experienced by excessive solution effect. It is suggested that this technique could be used to form a primary standard of crystal size to which other methods could be referred. The JKM requires considerable time and patience to ensure the accuracy of measurement needed. The frequency plots obtained give an excellent indication of regularity of crystal size.

The remaining methods can be completed in two hours or less. The Jeffries technique taking some 10 to 15 min. per field is generally accepted as the most reliable at present. It is a very laborious method especially when several fields have to be examined. Extra care is needed when examining twinned structures. The range of reproducibility of this method is little better than the general comparison methods somewhere in the region of $\pm$ 10 per cent.

The Intercept method can be made a little quicker than the Jeffries, but values obtained tend to indicate a slightly finer grain size. Notes in the American specifications indicate that differences may amount to as much as 10 to 20 per cent depending on shape of crystals. In an investigation of grain-size in aluminium Phillips[4] examined corelation between the Intercept and Jeffries method.

TABLE II—*Comparison of Grain-sizes. Jeffries and Intercept methods*

Jeffries			Intercept		
A	B	C	A	B	C
843	± 90	± 45	915	± 38	± 26
702	± 37	± 18	756	± 30	± 13
408	± 31	± 10	441	± 36	± 12

A.—Grains per sq. mm.
B.—Variation on 1 determination.
C.— „ 5 „

Table II taken from the paper shows the constancy of results. He found that a greater variation could be expected with a fine grain size, when using a standard magnification. Smaller grain-sizes are again indicated by the intercept method. The Jeffries method also showed a slightly higher chance of error, which is aggravated by restricting the number of counts to one. It was stressed that the two methods could not be used interchangeably.

The American investigation alleged that comparison of grain-size values between different

laboratories was very poor using intercept technique. Variations within one observer were almost as bad as that between different observers. It should be noted in this instance that only three laboratories co-operated in this section of the work. The technique is most suitable where elongated crystals are observed, such as in aluminium, magnesium, and their alloys, as well as lightly worked materials. It is not so tiring as the Jeffries method, but results are not so consistent. The use of longer intercepts rather than decreasing magnification does improve reproducibility slightly. Length of intercept is of course determined by screen size.

The comparison techniques are widely used and are relatively quick. These methods allow several fields to be examined rapidly. The method in which the projected image is compared with a set of opaque prints or transparencies tends to be quicker than using a single standard, and altering the magnification of the image, but variation in reported values tends to be higher.

A projection microscope, which is not always available in works test laboratories, is essential for the comparison methods. For this reason it is common practice in a number of commercial laboratories to view the specimens with a bench microscope, comparing field of view with prints of standard structures. In this way several hundred specimens are examined in a day. There are, of course, objections to this direct viewing. One is that magnification is not easy to standardize. Microscopes found in routine test labs. seldom have provision for variation of magnification other than change of eyepiece and objective, the tube length is usually fixed. Linear magnification may be determined for visual examination by using the following([5]) :—

$$M = \frac{t}{f} n$$

Where T = tube length.
f = focal length of objective.
n = magnifying power of occular.

This is reasonably accurate where T is large in relation to f. Some manufacturers simplify matters by quoting objective magnifications.

TABLE III—*Magnification*

Tube length	Objective	Eyepiece
160 mm. fixed ..	16 mm.	× 7½ required for 75 magn.
200 mm. extension	16 mm.	× 6 required for 75 magn.

Lighting for specimen illumination and print viewing is generally unsatisfactory. The standard charts, often internal laboratory copies of accepted standards, are pinned in frames on the wall. This involves the operator continually glancing up from the microscope to make comparisons. The microscopes receive scant maintenance, which allows dust to accumulate, reducing contrast and brightness of the image. The operator is often working with the production metallurgist breathing down his neck waiting to rush the results to the works.

In spite of the objections and difficulties, it has been found that careful laboratory staff are capable of returning consistent and accurate results. Adequate training, supervision and checking of laboratory personnel engaged in this routine work help to maintain a consistent standard. Operators can be easily classified into groups reading high or low, and results can be judged accordingly. When direct viewing is practised known samples should often be included in batches of work. Laboratory people should also be allowed to do check tests using one of the quantitative methods. It is not recommended that the magnification should be altered to adjust the size of image, so that it approximates to one of the prints on the standard chart. This practice is permissible to a limited extent when the image is viewed on the screen, a modification tentatively suggested by A.S.T.M.

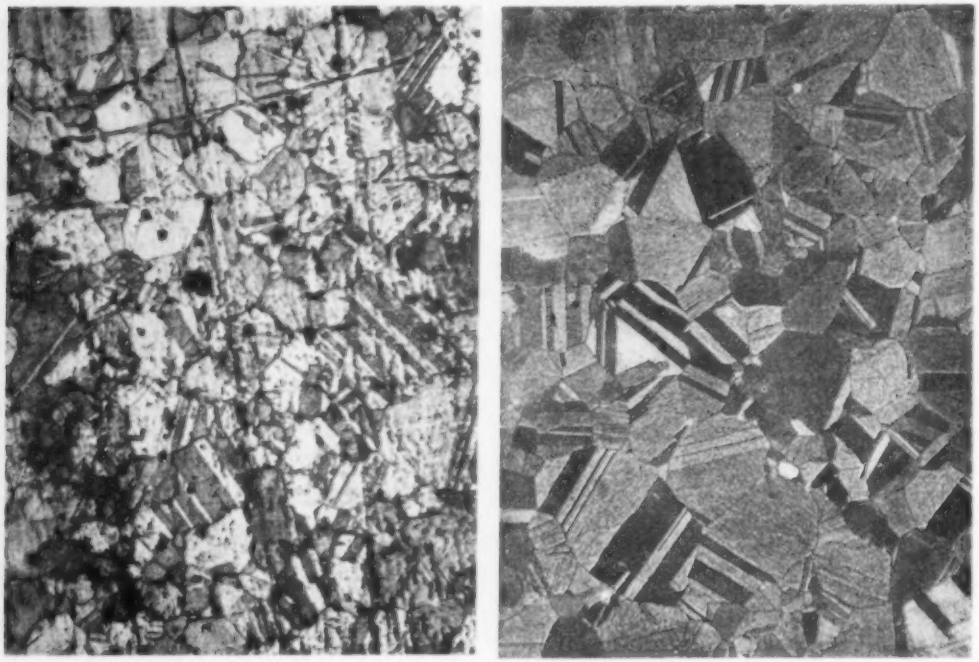
The use of an eyepiece graticule having an ideal cell network at first sight appears attractive. In practice it has been found difficult to judge structures against this network, particularly where twinned structures are viewed. The use of a binocular microscope has also been considered. One eyepiece to view structure, the other set to view micro-prints or transparencies of known standards. The two fields can be seen simultaneously. Accuracy of focus and image planes creates a condition of severe eyestrain to some operators.

PREPARATION OF SAMPLES FOR GRAIN-SIZE EXAMINATION

Selection of Sample

The accuracy or consistency of grain-size estimations is largely dependent on the section taken and the quality of the prepared surface.

Most drawing or pressing operations stretch the sheet metal such that thickness is reduced and surface modified. It has been suggested that surface structure of the material is, therefore, of prime importance. As a result of this there is a tendency to examine the surface of the sheet for size of crystals. This simplifies the examination procedure, since the method lends itself to coarse methods such as deep etching or pickling of the sample, with little or no attempt at surface preparation. This method has been cited for grain-size examination in aluminium. This practice cannot be too severely condemned. Deep etching will mask the presence of smaller grains, and twinned structures present appearances that are difficult to



(*a*) *light polish and deep etch* (*b*) (× 150) *same field after removal of* 0.010 *in. by electropolishing*

Fig. 6.—*Effect of insufficient preparation on the appearance of the structure of the surface of a sample of* 70/30 *brass*

judge (Fig. 6). Another although somewhat restricted practice is surface examination of copper samples, after removal from annealing in a cracked ammonia atmosphere. Grain boundaries outlining grain shapes can be clearly seen. Repolishing and etching the copper will, however, indicate a very different structure.

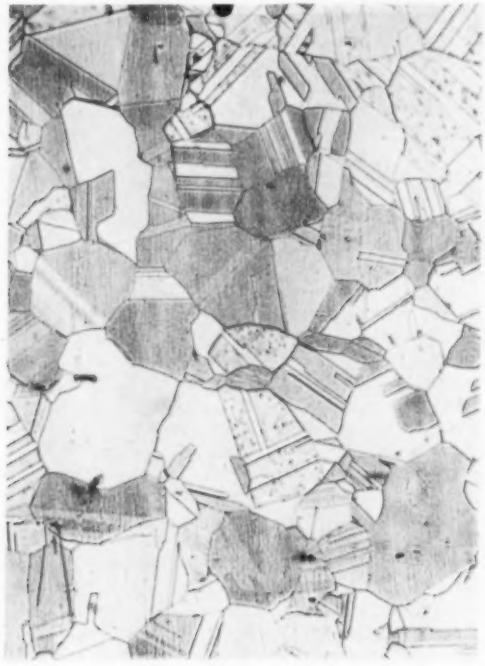
If surface structure has to be examined it should be ground to at least 4/500 grit and then either chemically or electrolytically polished. Hand polishing on small thin specimens is not easy and there is a tendency for this operation to be poorly done. Electrolytic polishing may be carried out with the simplest of equipment (at least for copper), 12v. accumulator charger, 100 ohm. resistance, voltmeter, and a beaker holding the phosphoric acid. Polishing takes place at 1.2-1.7 volts depending on age of solution; and time varies from 3 min. for 500 mesh ground surface to 30 sec. for lightly-hand polished surface. More expensive commercial units will polish areas of 1 sq. cm. in 15/20 sec. from a ground surface.

Chemical polishing does not require any expensive equipment, and the solutions although highly corrosive are very stable. One disadvantage with the solutions is temperature; this has to be kept at 70° C. or above with consequent evolution of fume. Table IV gives typical solutions.

Sections through the thickness of the sheet will indicate important variations of crystal size from surface to centre. Chance sections often reveal existence of internal flaws, and variations of crystal size from edge to centre resulting from the persistence of the "as-cast" crystal structures. Rimming steels have a surface zone of relatively

TABLE IV

	HNO_3	H_2SO_4	H_3PO_4	H_2O		Temp. °C.
Fe	3	—	—	30	7 HF	70
Ni	30	10	10	—	50 acetate acid	90
Cu	30	10	10	—	50 acetate acid	70
Al	5	25	70	—		110
Zn	150/200 gm. Cr_2O_3 + 10 ml. saturated Na_2SO_4 + 5 ml. HNO_3 in 100 ml. water at room temperature.					



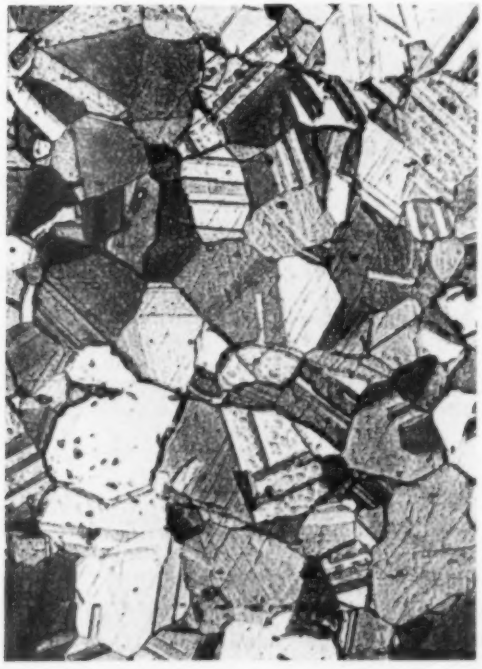


Fig. 7 (× 150).—*Effect of degree of etch on the appearance of a twinned structure. The three photomicrographs are taken on the same area after,*

(*a*) (*top left*).—*light etch*
(*b*) (*top right*).—*medium etch*
(*c*) (*left*).—*heavy etch*

pure iron, and here the crystals are slightly larger than those of the centre. Basis quality brass, 63 per cent Cu. sometimes shows ghost bands of fine grains along the centre of section, it is suggested that these are due to residual β phase from casting. Where crystal size is equiaxed, choice of section should not make any difference to the assessed grain-size. Longitudinal sections, however, make it easier to see small stringers of second phases or inclusions. For routine control work, a single section is usually sufficient, where investigation of failures is contemplated it is advisable to examine several sections. It may even be necessary to use taper sections across the thickness in order to examine more closely variations of structures.

Preparation

Specimens from several sheets can be clamped together between thick plates of similar material. The pack is best prepared with samples of standard size that just fit between the bolts. This avoids undue bowing of the clamps which leaves gaps between the specimens to trap abrasive and liquids.

The pack is then prepared for metallographic examination by grinding and polishing. The final polish may be mechanical or electrolytic. Where possible a light electrolytic finish should be used to improve the surface. The quality of surface preparation of routine specimens is just as important as with any other metallographic specimen, this fact is not always appreciated. Prepared surfaces are often so distorted that no clear picture of the structure is possible. Routine grain-size checks are required in a hurry, and several lots of 20 or 30 samples can be received in the laboratory at frequent intervals. The longest part of the work is the sorting, cutting, mounting and polishing of the specimens, estimating grain-size occupies less than 10 per cent of total time. Samuels has shown that indifferent preparation procedures cause severe distortion to 100/150μ below the polished surface. It is essential that all abrasives used in the early stages are sharp and contribute to a clean cutting action. Preparation time should not be cut at the expense of inadequate grinding. Clean clear structures can be obtained by alternate polishing and etching the specimen, usually more successful with steel specimens.

Etching

The crystal structure is revealed by treating the polished surface with a corrosive liquid or gas. The function of the etchant is to dissolve some of the metal and attack follows along well defined crystallographic planes. Since in a random structure grains will present these easily attacked planes at various angles to the surface, speed and depth of attack will vary from crystal to crystal. A randomly orientated structure after suitable etching will show a range of light reflections. This gives a contrast etch which is not always required or suitable for structure examination. It is sometimes better to delineate grain boundaries only, using less active reagents. In either case etching procedure should be adjusted to avoid pitting or pickling of the specimen. An overetched specimen shows shallow escarpments where thin boundaries should exist and centre of grain appears rough. (Fig. 7 shows appearance of etched and overetched specimens.)

TABLE V—*Etching Reagents*

Ferric chloride in alcohol iron, nickel, copper	General contrast (non-stain)
Ammonium persulphate copper, zinc	Grain boundary
Ammonium persulphate + HCl iron, stainless steel	Grain contrast
Ammonium hydroxide, hydrogen peroxide, water, copper and alloys	Excellent contrast

Copper and the solid solution alloys, nickel stainless steels and zinc are not difficult to etch and depict structures clearly.

Aluminium and the work hardenable alloys present a somewhat different problem. Since aluminium is relatively soft, more skill and care is needed to prepare metallographic specimens. Grinding is best done using papers flooded with paraffin, a messy operation that invites excess paraffin. Waterproof carbide papers are not so efficient, the grit rapidly wears and leaves bare paper. Aluminium oxide or magnesium oxide may be used for polishing; diamond dust is far superior, although expensive in spite of precautions taken to economize. Grain contrast after etching is seldom satisfactory; most of the reagents such as caustic soda and acid solutions based on hydrofluoric acid tend to pit the specimen badly. Electrolytic etching has been shown to be very successful[9, 10] using solutions of approx. 2½ per cent perchloric acid in glacial acetic acid and a potential of 24v. To avoid the use of perchloric acid the specimen may be anodized and then viewed with polarized light. The best results are obtained if the specimen is electropolished before anodizing. The anodizing may be done in a simple cell using 20 per cent sulphuric acid and 12-24 volt a.c. (Small transformer normally used for bench microscope lighting is suitable.) Using a.c. two specimens may be anodized at the same time.

Polarized light can be used to improve grain contrast on zinc and some nickel-alloy specimens and polaroid screens to give polarized light can be quickly and cheaply fitted to any bench microscope.

The finished specimen must be thoroughly washed and dried. Water stains and dried etchant will mar the surface. A difficulty experienced with a clamped pack of sheet specimens is the seepage of moisture from between the specimens. This presents two problems:—

(*a*) Staining of edges of the specimen;

(*b*) Clouding or steaming of the lens.

There is no quick way of avoiding this; soaking of the specimen in a volatile liquid such as acetone or methylated spirits, and then drying in a hot air blast tends to minimize the frequency of this trouble. The air blast should not be excessively hot as this tends to oxidize copper and brass specimens, particularly after a ferric chloride etch.

Regularity of Crystal Size

Reports on grain-size frequently refer to structures as "irregular" or "slightly irregular." How far are these terms justified? These terms when applied to values assessed by comparative methods have very little significance unless the variation in structure is grossly exaggerated. In such a case the structure can only be classed as "irregular." The term average grain-size when

(*a*) (*above*) (*b*) (*right*)

(*c*) (*below*)

Fig. 8.—Representative irregular crystal structures
(*a*) 70/30 *brass.* × 75
(*b*) 0.08 *carbon steel.* × 100
(*c*) *copper nickel alloy.* × 25

quoted implies a small variation in size above and below the specified figure, and for all general purposes indicates a regular structure. The comparative methods are acceptable for assessing such structures. It should be remembered that a regular array of uniform solid forms would show a plane section consisting of a range of irregular areas.

Where irregularity of structure is thought to exist, then the range of grain sizes is best quoted. When a specimen exhibits a structure that is irregular there is very little doubt about the condition. It is seen to consist of areas of large crystals surrounded by masses of smaller crystals. This can be reported as an approximate percentage of each range (Fig. 8).

A quantitative method of assessing irregularity would be by measurement of areas and plotting a frequency curve. A grossly irregular structure will show two if not more peaks (Fig. 9). The shape of the curves indicating whether or not irregularity existed over a range. Volumes of similar shape show a definite ratio for maximum area—average area as seen on section. Hull and Houk found for various volumes the following ratios :—

Pentagonal Dodecahedron ..	1.69
14-sided	1.83
Sphere	1.5
Cube	2.14

Applying this to grains seen in practice a value of 1.8 was suggested for uniform grains. Variation from this figure indicates an irregularity in grain volume.

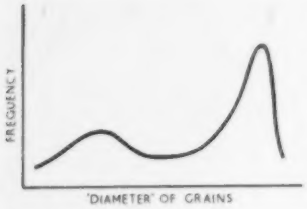


Fig. 9 (left).—Distribution curve of "diameters" for an irregular structure (diagrammatic)

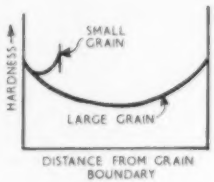


Fig. 10 (right).—Hardness variation across grains of similar state, but of different diameters (8)

Such long analysis methods are not considered justified for routine work, but would be of considerable value applied to deep-drawing problems associated with structure.

The above applies to irregularity of equiaxed grains. Aluminium often exhibits elongated grains like pancakes. Irregularity in volume is difficult to judge in this case. The section likely to give most information would be that parallel to the surface, although other sections should not be ignored. Where there is a core as in rimming steels this again constitutes an irregular structure; and due consideration should be given to the extent of the core and surface areas. Crystal size of each zone should be determined and quoted separately, they should not be given as a general average; this is meaningless. During annealing, furnace atmospheres may cause modification of the surface zones—giving rise to similar crystal variation effects, *i.e.*, decarburization of steels, or sub-surface oxidation in dilute copper-base alloys. Material that has been flash annealed should be examined closely since variations have been known to occur across width as well as thickness of sheet material. Irregular structures are often associated with small amounts of impurities or alloying elements, *i.e.*, phosphorus and iron in copper and copper zinc alloys. The effect is generally attributed to incomplete solution of the elements.

Importance of Regular Crystal Size

It has already been noted that properties depend on grain-size. The grain boundary exerts a restraining influence on slip during deformation, and as would be expected hardness varies from grain boundary to grain interior. Hardness variation in two grains on material of similar state may be illustrated as Fig. 10. Elongation will also be restricted near boundaries. Crystals of various sizes will therefore vary in their ability to strain harden and elongate. A coarse crystal structure may exhibit greater ductility than a finer structure but slighter strain hardening characteristics.

Drawn products that fail by necking can often be attributed to irregular structures. A difficult point to explain to the man in the press shop when he knows that production is successful with material over a wide range of regular grain-sizes. The position is made more difficult when it is realized that surface appearance of material with irregular structure is similar to that of material with a slightly coarser grain. The extent of the coarse grains in an irregular structure determines the surface roughness. Structures with 40 per cent or more coarse grain exhibit " orange peel " effects.

Rimming steels and decarburized steels exhibit a coarser structure at the surface than in the centre. As surface layers are relatively purer and softer drawing properties are determined by structure and thickness of the core. Surface appearance which may be related to finishing costs is dependent on surface structure. A compromise has to be made between suitable core structure to withstand the drawing schedule, and surface structure for appearance.

Influence of Crystallographic Directionality

Sheet material is said to be directional when it is composed of grains whose similar atomic planes line up to within a few degrees of each other. Such material exhibits surface textures typical of a coarse crystalline material, *i.e.*, surface after forming appears rumpled. The microstructure can be prepared such that a fine crystal structure is apparent, but grain boundaries in directional material are very difficult to reveal, and surface appearance of the micro specimen takes on a curious directional sheen. There can be no general way of reporting a structure of this nature. Reference must be made to the directional nature of the structure.

TABLE VI

Material	Etch	Atomic plane
Al ..	9 HCl, $3HNO_3$, 2HF, $5 H_2O$	(100)
Fe ..	$1HNO_3$, $4 H_2O$	(100)
Cu ..	1HCl, 1 $FeCl_3$ (Sat. Soln)	(100)
Cu. Zn.	As for copper + $1H_2O$ ..	(100) (111)

The degree of directionality of preferred orientation of a material may be determined by :—

(1) X-ray diffraction ;

(2) Mechanical tests :

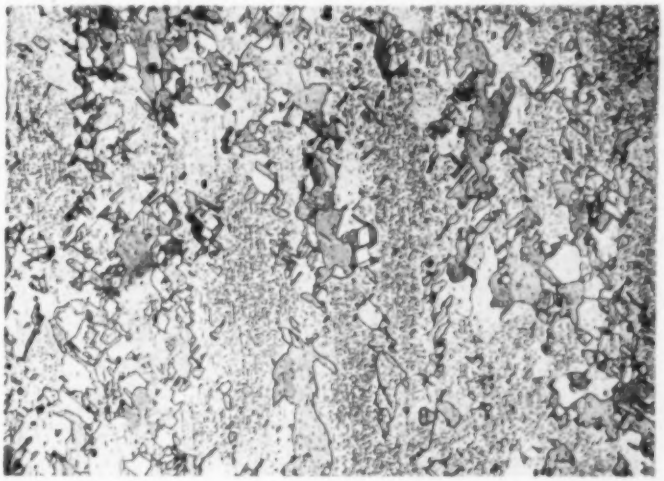


Fig. 11 (right).—Typical structure of a sample of directional copper specimen taken parallel to the surface of the strip. Note 45° angle of the majority of the twin bands. × 100

Fig. 12 (below).—Polar plots of twin frequency

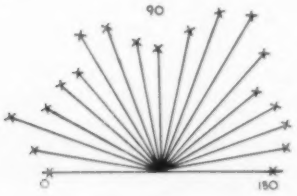
(3) Etching characteristics ;

(4) Frequency of some metallographic feature.

(3) and (4) can be considered further. It has been mentioned that certain etchants will attack definite crystallographic planes rapidly.

Crystals will then show up dark or light depending upon whether these planes are parallel to or at an angle to the surface. Materials having pronounced directionality often show a preponderance of white areas in the structure. Ferrite grains are selectively attacked by ammonium persulphate and hydrochloric acid ; directional material will show an excess of white area. Copper having a strong cubic texture (100) [100] treated with ferric chloride will also show excess white structure (Fig. 11).

This technique is applicable where etchant is very selective in attack, and the material develops well pronounced simple textures. To determine percentage of cubic aligned grains in aluminium, the specimen is anodized and then photographed, under polarized light, in two positions 0 and 45 deg. rotation. Identical grains on the two photographs are superimposed and the extent of dark area is a measure of the (100) [100] texture. A more refined technique of orientation determination is to make a critical analysis of the angles of etch pits.



In face centred cubic metals showing annealing twins, complex crystallographic textures can sometimes be assessed by a frequency plot of the angle of the twins. The frequency of each angle is laid on a polar plot-range 0-180 deg. Equiaxed structures with and without pronounced directionality would show diagrams similar to those illustrated (Fig. 12). This technique is time consuming but can indicate abnormal structures without the use of expensive apparatus.

Preferred orientation can also be detected by mechanical tests. It is the variation of tenacity and ductility that is responsible for failure of pressings in directional material. Failures due to anisotropy of properties can usually be detected by the localized nature of the splits, or "earing" of the rim of the product. Where material fails in a suspicious manner a polar plot of twin frequency would help in deciding the cause of failure.

Effect of Twin Bands

Structures in aluminium and iron showing simple polyhedral grain areas do not present a great deal of difficulty when assessing grain-size. Face centred cubic metals such as copper and nickel alloys develop parallel sided bands within the grain, which are visible after annealing. These are known as twin bands, and they have a different lattice orientation to that of the parent crystal. The bands thus present a barrier to slip band propagation during deformation. It is, therefore, reasonable to accept that these twins provide an additional strengthening effect similar to that of reduction in crystal size. There is no general agreement on method of assessing the size of a twinned crystal

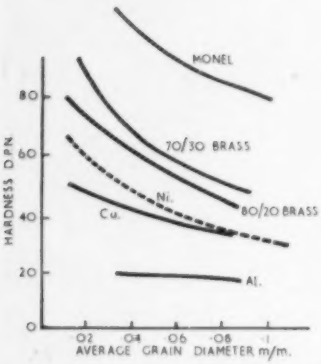


Fig. 13 (left).—Hardness/grain-size relationship

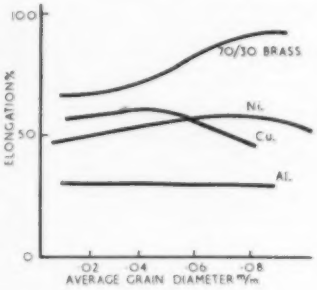


Fig. 14 (right).—Ductility/grain-size relationship

structure, to include the influence of the twins. Frequency of twinning is higher in 70/30 brass [11] than in copper or α solid solution tin bronzes. Attempts to modify the degree of twinning in these materials by working at very low temperatures before annealing have not met with any success.

Twin bands create some difficulty in locating actual grain boundaries. Twins that exist in grain corners are particularly annoying in this respect.

Influence of Grain-size on Mechanical Properties

With most metals and alloys, the strength properties, *i.e.*, hardness, ultimate tensile strength, yield strength, rise with decrease in grain-size. The breaking stress and reduction in area values do not appear to be affected. Fine grain material shows a tendency toward work softening after severe deformation.

Fig. 13 shows relation between hardness and grain-size for several materials. With copper and aluminium there is very little change in hardness, and small amounts of alloy element added to aluminium, do not modify the slope of the hardness grain-size curve. With other metals the hardness variation for small changes in grain-size is marked. Hardness, grain-size values taken from various sources (on Cu. Zn. alloys) have been analysed and found to conform reasonably well to a law

$$H_v = 34 \cdot S^{-\cdot 232} \left(\text{approx. } H_v = \frac{34}{5\sqrt{S}}\right)$$

H_v = Diamond pyramid number.

S = grain-size average dia., mm.

within the range of grain-sizes 0.010 mm.-0.1 mm. dia.

It has been suggested that hardness of materials could be compared by using the P_m value instead of conventional hardness. The P_m value has been alleged to be independent of grain-size. This value is the load required to sink a spherical indentor to its equator—reported as a "stress." It was found that copper apparently satisfied the independence, and recently it has been used to make comparisons between aluminium and its alloys. Attempts to apply this to 70/30 brass and 95/5 bronzes have proved unsuccessful. The P_m value varies in a similar manner to conventional hardness values.

Tensile properties show similar characteristics to the hardness [illegible] 1. There is little or no variation of ultimate tensile strength with grain-sizes in aluminium and its alloys. Other metals and alloys show marked variations. There are only small differences in trends between the pure metals and their alloys. When considering results from tensile tests due consideration should be given to thickness of specimen in relation to size of grains.

The yield-point phenomenon, once considered applicable to mild steel only, but now frequently observed in a number of non-ferrous alloys, is influenced by grain-size. Decreasing the grain-size raises the yield stress and causes the yield jog to be more pronounced. Associated with the yield point is the formation of stretcher strain markings. When choosing steel for forming, a balance between coarse grain, which will give a rough surface, and fine grain, which may give a crinkled surface, has to be made. It should be noted that the yield features are affected by speed of deformation. Increasing the forming speed for a given grain-size results in greater yield characteristics.

The ductility of single-phase metals and alloys is generally claimed to be better with coarse crystalline materials. If elongation in the tensile test is considered as an approximation to the ductility of materials, then wide variations can be seen. Aluminium shows no variation with grain-size, in fact it is difficult to see how formability of aluminium materials is affected by grain size. However, it is common experience that deep draws, and in particular impact extrusions are often better with coarse grain metal. Brasses 71/80 per cent Cu, α tin bronzes, aluminium bronzes and nickel silvers, all show marked increases in elongation. Increases of the order of 45 to 65 per cent for grain sizes 0.020 to 0.065 mm. diameter. No advantages are apparent with grain-sizes above 0.1 mm. unless very thick materials are considered.

Copper and nickel show an initial increase in ductility followed by a substantial decrease as grain-size coarsens. A grain-size of approximately 0.045 mm. dia. gives maximum ductility in copper.

Elongation as measured in a tensile test is the sum of general (or uniform) elongation plus local elongation. Local elongation is materially affected by specimen size and shape. General elongation is a property which has greater importance in forming, and it is a characteristic property of the material. This property is said to be improved by fine grain since fine grain allows rate of work hardening to offset reduction in section. The relationship between general elongation and grain size has received scant attention often as a side investigation to a main theme. A critical review of published work and a detailed examination of the effects of grain-size on general elongation and work hardening could prove very useful.

Effect of Grain-size on Work Hardening

The effect of grain-size on work hardening characteristics appears to be somewhat undecided. Curves shown by Kee indicate very little difference in working characteristics by rolling up to 50 per cent reduction for a 2-3 fold increase in grain-size. McLean indicates that strain hardening is affected by grain-size in the initial stages of strain, say, first few per cent. The later stages of stress strain curves are considered parallel. Analysis of the rolling curves (after Cook) by Voce indicates that characteristic strain, the function that determines the shape of the curve, increases as grain-size decreases. The Voce strain hardening function indicates two and possibly three hardening regimes. The characteristics strain of each regime varyies with grain size. Using the logarithmic function to analyze stress strain curves of 70/30 brass, Holloman shows curves that are similar up to 0.07 log strain. For strains 0.07 to 1.5 curves converge to an upper point, the coarser the grain the steeper the curve.

The strain hardening characteristics of a metal are important in deep drawing, and the relationship of grain-size to this characteristic would well repay close and critical examination.

Conclusion

The grain-size of a metal controls to a large extent the properties and formability of sheet. Insufficient technical consideration is given to its importance and estimation. Control of grain structure has received a great deal of publicity in the past few years, and the laws governing recrystallization and grain growth are fairly generally known. Plant practice is not so easy to control as laboratory experiments or pilot plant work. Therefore considerable skill and care is needed to select and examine samples from general production material. Structures produced under laboratory conditions are often easier to examine and interpret than samples from production processes.

The introduction of grain-size limits into specification standards will be greeted with alarm by most production people (another laboratory device by which material can be rejected), and some laboratories, (more work for an overworked section). The use of grain-size limits in specifications will, however, create an awareness of its importance, which could lead to a more consistent quality of sheet metal, at least as far as structure is concerned.

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Metallurgy of Deep Pressing and Drawing.—D. Jevons.
Grain Control in Metals—A.S.M.
1958 Tentative Standards.—A.S.M.
Introduction to X-ray Metallography.—Taylor.

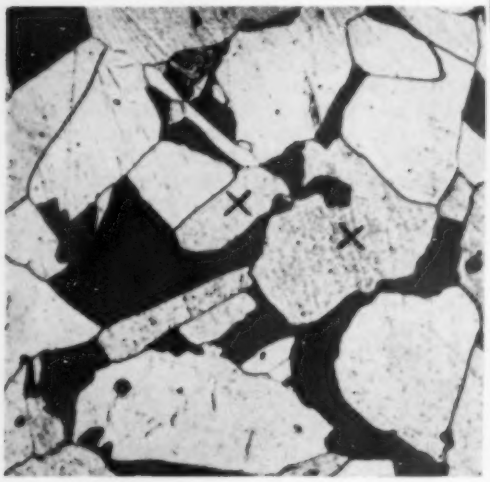
* * *

Introducing his paper Mr. James said that in it he had mentioned disintegrated stainless steel, and showed a photomicrograph of some of the crystals. He had been justifiably criticized for the poor photograph (Fig. 5)*. Unfortunately, the original samples had been mislaid, but some more samples had been disintegrated and he had that with him. He was surprised to see that the crystals were strongly magnetic.

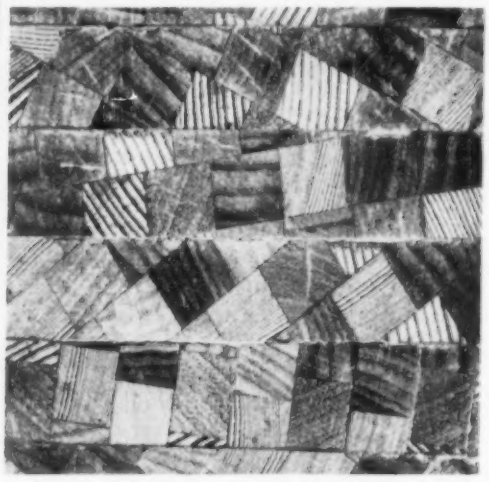
DISCUSSION

Mr. J. F. KAYSER (Gillette Industries Ltd.) said that this was one of many papers on grain-size which would be published because the subject was an important one. The question of grain-size was largely in the hands of the metallographers, and many of them seemed to forget that we lived in a three-dimensional, not a two-dimensional world. Crystals or grains were solid entities, and micro-sections shown on a slide (Fig. A), gave some idea of the difficulties. What seemed to be two grains, for comparison, were often, in fact, one grain, *i.e.*, after polishing they became one. Another grain, on the other hand, might divide. In a microstructure such as that shown in Fig. B, which was of a block of wood, could be seen triangular areas, five-sided figures, a wedge-shaped piece and more triangles. That agglomerate of wood was precisely 10 cu. mm. It was difficult to interpret the piece of wood into true grain-size. What was the position with a more complicated structure ?

* Now replaced by an improved illustration (*see* p. 188.)



(Fig. A) Typical microstructure



(Fig. B) Microstructure of wood

From a research point of view it would be worthwhile to determine the shape and true size of grains in a number of simple alloys. It would cost a lot of money—perhaps £50 or £100 per grain, (Mr. Kayser then showed a model of a grain of ferrite prepared in this way). He then said that it had cost a great deal of money and had called for the preparation of 49 micro-sections, all of one sample of steel. This was a simple but laborious process. The edge was polished and photographed, marking the sample in such a way that the position was known. Then a very small amount of metal was removed and another photograph taken. This gave a large number of contours of one grain. This would be a research job but it would be well worth doing.

For thin sheet metal, would it not be sufficient to polish a cross-section and as an estimate of grain-size merely count the number of interfaces given by a run at right-angles to the surface ?

Mr. JAMES replied that Mr. Kayser had shown a remarkable model. The suggestion was that with a section of thin material it was possible to estimate the grain-size by making a count across the section. This had been done in the work he had mentioned on elongation and grain-size. With 0.07-in. sheet a line had been taken across the sheet and a measurement made of the number of grains intersected by that line.

With thin foils 0.003 to 0.005 in. thick the count given by the intersections across the width was not the same as grain-size values estimated by the comparison methods.

This was a feature which had puzzled him when in the industry, but he had not taken up the matter since. It had been obvious from several observations of this type at different times that counts across a section did not tally with the grain-size estimates made by comparison methods, whether the comparison methods were conducted by looking down upon a micro-section and comparing the field of view or by the Jeffries count method. They had not tallied—but he did not know the reason.

Dr. B. B. HUNDY (Steel, Peech and Tozer) asked how the author would measure the accuracy of the grain-size of a 0.15-per cent carbon steel with ferrite and pearlite grains.

Mr. JAMES replied that he would first make sure that the grains of pearlite were pearlite and not polishing defects. Having established this, he would estimate the amount of ferrite, the crystal size of the ferrite and the approximate size of the pearlitic areas. In low-carbon steel there were usually films of carbide which would probably have to be taken into account. He would estimate the amount of ferrite and pearlite and look carefully for signs of inter-granular carbide, which he would also report.

Dr. HUNDY asked how he would measure the size of the grains, and Mr. JAMES replied that he would do so by comparison (for routine work) by looking down on a micro-section. If he had the facilities and the time he would use the Jeffries count method, estimating the grain-size on two planes at right-angles to one another.

Dr. HUNDY pointed out that in counting the number of ferrite grains the author was ignoring the area occupied by the pearlite and would get the wrong answer for the ferrite grain-size.

Mr. JAMES replied that he estimated the area of the ferrite and the area of the pearlite and gave it as a total value, so much percentage of ferrite grains of such-and-such a size and so much area of pearlite.

Dr. HUNDY asked what accuracy was expected by this method.

Mr. JAMES replied that American publications claimed an accuracy of plus or minus 20 per cent.

Dr. E. MARKS (Richard Thomas and Baldwins Ltd.) said that Mr. James had been a little unfair to the industry in this country by suggesting that they were frightened of control of grain-size. He was speaking only for the steel industry, but they had been doing it for 30 years. This control was used every day.

He was puzzled by the statement in the paper that structures produced under laboratory conditions were easier to examine than samples from production processes. Would Mr. James explain what he meant by that?

Mr. JAMES replied that his knowledge was mostly restricted to non-ferrous work. The little he had had to do with steel micro-structures was with metallurgical complaints. But the inspectors and the people responsible in the shops had shown a marked indifference to the effect of grain-size and its importance in their components, and they had been surprised to be told about it.

Again speaking from the point of view of copper and brass, particularly brass, in work dealing with recrystallization and grain-size he had found that the structures of laboratory-treated specimens gave much clearer grain contrasts than some specimens taken from normal production. The range of contrasts varied, but on the whole specimens taken from production for examination were not so easy to bring up with a clear contrast as were specimens from the laboratory. This was mainly because in the latter case the very small specimens were heated under ideal conditions, and presumably the crystal growth process was more nearly complete.

Dr. A. J. K. HONEYMAN (Steel Company of Wales Ltd.) suggested that the title of the paper should be "Grain-size—Its measurement and significance in relation to cold forming" not "in relation to cold rolling."

Could the author make any observations on the effect of grain-size on the ageing of non-ferrous metals? The effect on steel was well known.

Mr. JAMES agreed with the comment about the title of the paper. He had been given a choice of subjects in relation to cold deformation. The title should be wider than "cold rolling." He had no comments to make on the effect of ageing on grain-size.

Mr. NUTTING (Wilmot Breedon Ltd.) said that the measurement of average grain-size worked on the assumption that there was uniformity throughout the structure. Would not the quickest and probably the most accurate method of measuring grain-size be based on measuring a specified number of the largest diameter grains within a given area?

Mr. JAMES replied that such a method would approximate to the frequency grain-size method advocated by Swedish workers. It involved making an estimate of the large-sized grains by comparison, and this approximated to the Swedish method. He thought that there was no objection to the use of the largest-diameter grains except that, apart from the influence of regularity, these were not the truly largest diameters of the grains in the section. Some Americans had taken a number of regular figures and had done a considerable amount of work in determining the frequency of areas of various planes and sections, and this had shown that the largest number of areas of maximum size was below that of the apparent maximum diameter of the figures. The maximum diameter seen on the section was 0.9 to 0.95 of the maximum diameter of the regular solids. For grains the proportion would be even less—probably 0.85 to 0.9 of the true diameter of the grain, if a true diameter of a grain was possible. Metal grains were not at all regular.

By disintegrating stainless steel a fantastic number of shapes was obtained. These were not even straight-edged. Sometimes they had not even convex boundaries; most of the boundaries appeared to be concave. There was no regularity at all in size or 'diameter' of the crystals which he had seen after disintegration.

Mr. H. J. HARTLEY (Henry Wiggin and Co. Ltd.) commented that it seemed to him that there was a great danger of people thinking that measuring did not matter and specifications were written in to the great discomfort of the metallurgist and chief inspectors of various companies involved in producing and using materials.

The important point was not only to find out how accurately the hardness and other measurements of various grain-size could be determined but also to know what was their true significance and then, in any questions which arose, to talk the matter over sensibly and not to allow the discussion to take place between people who did not know the difficulties.

A university professor for whom he had great admiration normally told his students at least once a fortnight "For heaven's sake, do not keep your

(*Continued in page* 202)

Grain Size—Discussion

(*Continued from page* 201)

thinking in watertight compartments." This comment applied to the discussion of the difficulties outlined in the paper.

Mr. THWAITES (Tin Research Institute) made some observations on work which he had carried out several years previously on lead alloys extruded in the form of rod. He had been studying the creep properties, and one part of the research had been to discover the effect of grain-size on creep properties. This involved grain-size measurements, for which three techniques had been used. The first was the comparison method, and this was quite rapid. The second method was that of Hull's suggestion mentioned by the author in which the frequency of certain sizes in a cross-section was measured. Subsequently, as a third method, it had been suggested that the mathematical treatment should be to consider the specific grain-size and the grain volume.

Three values had been obtained in plotting the potential properties against the three different values for grain-size ; and exactly the same results had been obtained. The conclusion had been that the relatively quick comparison method was as good as any.

In making the measurements, the ordinary straightforward extruded material had been simple to handle because there had been fairly large grains, not " twins." With material extruded at low temperature there had been a few " twins " and it had perhaps taken a little longer to make the comparison and had required a little more care.

Certain materials had been heavily cold rolled and flash annealed, and these had presented difficulties because no normal grain boundaries had been found at all. There had been a mass of " twins," and it had been virtually impossible to obtain a measurement of grain-size.

He was interested to hear that so far there was no method of measuring such a grain-size. This problem must be tackled because there were many cold-worked materials for this type of structure.

Mr. JAMES said he agreed with all Mr. Thwaites' comments.

Mr. R. BUTCHER (Mond Nickel Co. Ltd.) asked whether there had been a typing error in Fig. 5 in the reference to stainless steel, for the paper stated that the steel used was EN58c. This was in fact a stabilized steel which was not susceptible to intergranular attack of this kind.

Mr. JAMES replied that there was no mistake. It had been purchased as EN58c and confirmed as EN58c. It had also been found to contain 10 per cent nickel. It had been analyzed for titanium but none had been detected. The material had obviously not been supplied to the specification asked for.

Mr. BUTCHER pointed out that the presence of titanium was the crucial point.

Mr. JAMES replied that the supplier had said that the steel was EN58c.

Mr. BUTCHER suggested that this point should be checked. He thought it probable that the steel had contained no titanium.

Mr. JAMES replied that the steel had been given a drastic treatment. It had been heated at 1000° C. to coarsen the grains. Afterwards it had been heated in a furnace at 700° C. for two days. This had been an accident ; it should have been left for one day, but he had forgotten about it. It had been allowed to cool in the furnace, and it had disintegrated in a matter of hours in copper sulphate.

Mr. BUTCHER pointed to a comment on page 4 of the paper that austenitic stainless steels were relatively easy to disintegrate by slow cooling from 700° C. over 5 to 6 hours, and treating in boiling copper-sulphate sulphuric-acid solution. This was a sweeping and generalized statement which applied only to unstabilized steels and not to those stabilized with titanium or niobium.

Mr. JAMES showed a sample which had been in the furnace at 700° C. It had been bought as soft material, at 170 Vickers, measured with a heavy load and a deep impression. This, again, was EN58c, alleged to be stabilized. It had been in the furnace for one and a half hours at 700° C. the previous day and on the whole had disintegrated quite quickly. He still had some of this material and he would check it for titanium.

Diamond-Pyramid Indentation Hardness Measurement—Discussion

(*Continued from page* 183)

closest possible collaboration with the user and to exchange results and samples. German opinion was that there was no such thing as a unique hardness value for a metal and the suggested procedure was to agree upon a sample and send it to a well-known authority for hardness measurement. He might say, " This is 150 Vickers." Another person might measure the same sample and under his conditions of measurement read 170. He would then know that he had a personal error of +20.

He did not think that this was a very good procedure, but it had been recommended by Professor Rossow, who had pointed out that highly skilled and trained men working in the same laboratory often could not agree to a measurement within several microns, even when they knew what other men had given as a measurement.

CONTROL OF THICKNESS of Metal Sheet and Strip

By JOHN TOBIN, A.M.I.Mech.E.* and HAROLD J. HARTLEY, M.Sc., F.I.M.*

(*A paper presented at the Annual Conference of the Institute of Sheet Metal Engineering, London, November 11 and 12, 1959.*)

Introduction

THICKNESS is one of the important parameters determining whether a particular sheet or strip will satisfy the user's requirements. Consequently, the need for precise control has intensified steadily with the transition from craft metal work to mass-production methods. Simultaneously, the demand for sheet and strip has grown very considerably leading to revolutions in production methods, particularly in respect of the speed of rolling. Increase of speed has in turn introduced new problems in relation to control of thickness.

In considering the problems of control, it is essential to recognize at the outset that thickness and shape must be considered together (shape refers to flatness, straightness and edge to edge variations of gauge) and also that the cold-roller inherits problems which are generated by the previous history of the stock he has to work.

In recent years many papers have been published on the theory of rolling and latterly on systems of automatic gauge control. Necessarily these papers are more or less mathematical and specialized. The few accounts of the causes of variation in gauge of sheet and strip of which the authors have taken note, appear to have been written by theoreticians. The present authors have chosen to present the subject partly in the light of historical development and throughout from the point of view of the producer whose primary concern is the manufacture of sheet and strip in specialized materials. In such case rolling remains predominantly a craft. Nevertheless, management must often seek to participate in the benefits which derive from the advances in techniques which have been developed primarily for the benefit of the very large producer.

*Henry Wiggin and Co. Ltd.

Development in Rolling-Mill Design

In the early days of the art all rolling of flat metal was carried out using two-high mills (Fig. 1*a*). Such mills consist of a pair of rolls, with integral roll necks of much less diameter than the roll proper. The first attempts to obtain greater rigidity, and so reduce bending of the rolls, naturally took the form of increasing the roll diameter. This method is very effective for the break-down of slabs, since it permits the use of greater reductions in

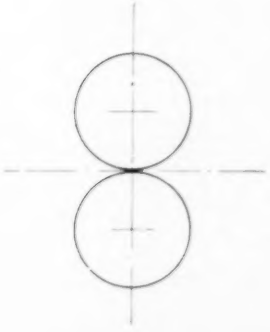


Fig. 1 (a) (left).—Roll arrangement for a 2-high mill

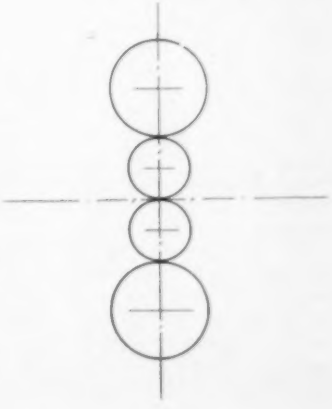


Fig. 1 (b) (right).—Roll arrangement—4-high mill (Work rolls driven)

Fig. 1 (c) (left).—Roll arrangement—cluster

Fig. 1 (d) (right).—Roll arrangement—Sendzimir

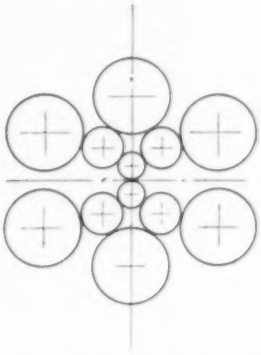


Fig. 1 (e) (below, right).—Roll arrangement—Rohn or Sendzimir

thickness per pass. It fails, however, when thin sheet or strip are required.

The reason for this apparent anomaly depends on a combination of effective surface friction and roll flattening. The maximum angle of contact is a function of the surface friction—consequently the maximum reduction in thickness depends on the diameter of the rolls. Surface friction increases with contact angle and this angle increases for a given thickness reduction as roll diameter decreases. Moreover, roll flattening is most serious when the contact angle is small. Thus the smaller the work roll diameter the greater the percentage reduction which can be effected on very thin strip. Rollers frequently speak of "grinding wind"—meaning that no appreciable reductions are being obtained. The limitations of large diameter rolls were readily recognized, and the first solution to the problem was to build a four-high mill (Fig. 1*b*). Here two relatively small diameter, directly driven, work rolls are backed up by two larger diameter rolls, the aim being to combine the rigidity of large rolls with the ability of small rolls to bring about effective reductions when rolling relatively thin sheet or strip.

Two limitations of the four-high set up gradually emerged. It became clear that it is not easy to ensure that the axes of the four rolls shall lie in the same plane, nor does this arrangement prevent bowing of the rolls in the horizontal plane. Thus the decrease in size of work roll was substantial, but very definite limits were set by the tendency towards horizontal bowing, and the limited torque which can be transmitted by the small-diameter roll necks. This is discussed in greater detail under heading "C.M.P. Mill."

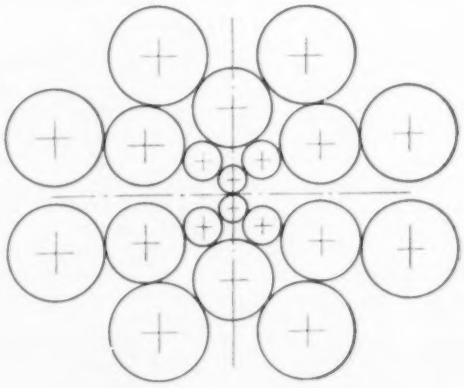
The cluster mill (Fig. 1*c*) was the first attempt to overcome this difficulty. The simpler cluster consists of a pair of work rolls, each supported by a pair of back-up rolls. Here there is a very practical geometric limitation in respect of the ratios of diameters of work and back-up rolls, and also the roller is very much inclined to criticize the arrangement on the grounds that the work rolls are inaccessible.

The cluster mill was modified by Rohn into a mill having an arrangement 1, 2, 3, 4, etc., thus developing a considerable degree of stiffness, though at the expense of elaboration (Fig. 1*e*). Later Sendzimir improved on this design.

Steckel, who is sometimes credited with the invention of the four-high mill, introduced a mill which was completely undriven, on which a powerful coiler supplies all the force necessary and this mill was extremely successful for rolling long coils of strip.

The action of a Steckel mill is very similar to that of wire drawing. The compression component of the rolling force is supplied as a resultant of the tension applied to the work emerging from the mill and clearly there will be a definite limit to the tension which can be employed, determined by the tensile properties and cross-sectional area of the work. It follows that the percentage reduction obtainable per pass is strictly limited.

Since all the rolling force is provided by the tension applied to the strip, it is essential to provide



powerful coiling mechanisms and, in view of the limited reductions possible per pass, to make the mill reversible and symmetrical.

Considerable decoiling tensions are also applied and these are generated by specially designed friction brakes. High speeds are also employed whenever possible and, consequently, a considerable amount of heat is generated and very special cooling arrangements are necessary. These include cooling drums either side of the mill over which the work passes to and from the mill.

The provision of these cooling drums permits a novel method of gauge control known as the Steckel-Lamb patent gauger. The cooling drums are driven by the ingoing or outgoing strip and will, therefore, rotate at speeds the ratio of which is determined by the elongation produced. The two drums are, therefore, coupled through pick-off gear boxes arranged to suit various reductions from 5 to 25 per cent to a differential gear box and thence to a tell-tale disc. The tell-tale disc will remain stationary if the desired reduction is obtained and the direction and speed of rotation, if any, will indicate to the roller the direction and degree of departure from the desired reduction.

In order to use the Steckel-Lamb gauge effectively, it is essential to produce strip of a uniform pre-determined thickness at the first pass on the mill and, for this purpose, the mill is controlled by reference to a suitable form of continuous gauge. The initial pass thickness and reductions for the following passes are, therefore, planned before the commencement of rolling.

It should be emphasized that all the mills so far discussed suffer to various degrees from the effects due to elastic mill housings and deflexion of the rolls and that it is still often essential to employ camber, either of work rolls or of back-up rolls in order to produce good quality sheet or strip. The use of extremely heavy rolling tensions does, however, contribute greatly to the simplification of the roller's problems. In the first place, if both entry and exit tensions are sufficiently high, there will be a substantial decrease in the roll-separating force required for a given reduction, thus reducing the bowing of the rolls. Second, high values of entry tension exercise a beneficial effect in respect to the behaviour of the ingoing strip by preventing wander across the rolls and discouraging the gathering effect which may otherwise occur during the rolling of thin strip. Third, sufficiently high exit tensions will stress the rolled strip locally beyond its yield point and so rectify to a large measure some of the local defects, *e.g.*, by reduction of the magnitude of edge frill, the presence of which is evidence of a full middle to the strip.

Shortly before World War II, Sendzimir elaborated the cluster design by introducing rows of roller races instead of solid rolls for the outer set of rolls in a 1, 2, 3, or 1, 2, 3, 4 cluster design (Figs. 1*d* and 1*e*). Although clearly deriving from the cluster mill, the Sendzimir mill incorporates two entirely novel features. The outer set of rolls are replaced by roller races with especially heavy outer shells and the mill housing is made from a single massive steel casting instead of two side frames connected by relatively flimsy tie bars (Fig. 2). The upper and lower halves of the casting are designed for rigidity and, by means of supports interleaved between pairs of roller races, this rigidity is transferred to the stationary shafts on which these races are mounted. The majority of these supports are fixed, but, by providing individual adjustments for the supports for one or more shafts, it is possible to simulate the effect of camber without recourse to cambered rolls. Suffice it to say that Sendzimir opened up the way to the use of extremely small-diameter work rolls and obtained excellent control of roll deflexion in all directions even when the mill was designed to roll wide strip. Latterly, the principle has been extended to the rolling of sheet.

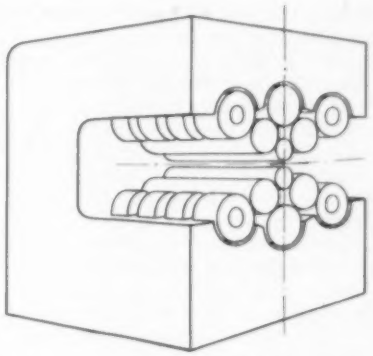


Fig. 2.—Diagrammatic arrangement of frame (cut away) of Sendzimir mill

Sendzimir was forced to drive his mill at some point intermediate between the work rolls and the outer row of races. Small diameter rolls cannot transmit the necessary torque and the races are of necessity free running. He also emphasized the necessity to employ very considerable strip tensions and his series of patents is extremely interesting. In these he makes it plain that the use of sufficiently large tensions can be extremely beneficial in control of gauge and shape. These benefits are obtained only when the tension on the outgoing side is very close to the yield point of the strip emerging from the mill. Under these conditions the yield point may be exceeded locally, resulting

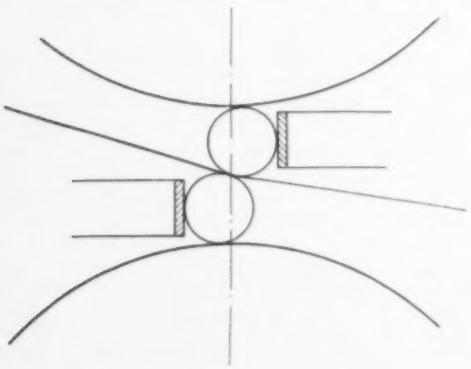
in stretching and so resulting in a good match of centre and edge lengths.

Cold Metal Products have more recently modified the Steckel mill by driving the back-up rolls. Here again very considerable tensions are used. They claim that in the undriven Steckel the slender work rolls bow towards the outgoing side of the mill, whereas, under driven conditions and low tensions, the bowing is towards the ingoing side. Theoretically, at least, it is possible to cancel out the horizontal bowing by partitioning the driving effort between the work rolls and the coiler. Moreover, the indirect drive to the work rolls (*via* the back-up rolls) permits the use of more slender rolls and especially of tungsten-carbide rolls, since this form of drive eliminates torsion in the work roll.

One clear advantage of the C.M.P. mill over the Sendzimir design is that there is no difficulty in changing over from one work-roll diameter to another when the back-up rolls of a four-high mill are driven. On the other hand, Sendzimir has designed mills employing $\frac{1}{4}$-in. diameter work rolls which are very useful for the production of thin foil, whereas C.M.P. do not quote in their patent roll diameters below $1\frac{1}{2}$ in.

A novel cold rolling mill for the production of very thin strip was recently invented by Lord[1] and has been developed by the National Research Development Corporation[2]. By the use of an insert (Fig. 3) designed to prevent horizontal bowing of the rolls, Lord was able to design a four-high mill utilizing extremely slender work rolls. Very heavy reductions of the order of 50 to 80 per cent in one pass may be obtained on this type of mill, which has been proved capable of rolling good quality foil down to 0.0002 in. thickness in a wide variety of alloys. Success in rolling on this mill is entirely dependent on the use of high values of tension. So far the difficulties of embodying automatic gauge control have not been solved.

Fig. 3—Lord mill, insert arrangement



The Production and Conversion of Ingots

Ingots in general suffer from various defects and it is usually essential to clean up the surface either before or shortly after the breaking down operations. It is only necessary to draw attention to the fact that, if the scarfing operations result in very uneven removal of metal, this may result in a persistent lack of uniformity and the effect of this is more serious the later the scarfing occurs in the production cycle. When the initial break down is by hot rolling, considerable lateral movement of metal is possible in the early stages, but such lateral movement becomes slight (except at free edges) towards the end of hot rolling and during cold rolling.

Hot Rolling

During hot rolling the metal itself will suffer some serious loss in temperature unless the speed of rolling and reductions involved are great, and considerable heat will be imparted to the rolls. Significant variations in temperature and consequently in diameter will develop along the length of the rolls and such changes may develop over a long period of time. Such changes affect the dimensions of the roll gap and thus the average gauge of the hot-rolled product. Since, however, these changes may not be uniform over the roll face they may also lead to variation in thickness from edge to edge of the product.

The methods adopted to correct for these changes in hot rolling must depend on two major factors :—

(*a*) The design of the mill ; and

(*b*) On the particular metal being rolled ;

for, while some materials are comparatively insensitive to the use of cooling water on the rolls, others will develop serious edge and surface cracks due to the surface chilling resultant upon the use of water.

Before considering the methods adopted for control during hot rolling, it is essential to consider the principal factors which affect the performance of a rolling mill. The local intrinsic loading on the rolls depends on the characteristics of the metal being rolled, sensitive to both temperature and speed, and on the severity of the rolling reduction. The rolls will consequently deflect, mainly in a direction normal to the work, and also some flattening of the rolls will occur. To overcome the deflexion using a simple two-high mill, it is necessary to introduce some camber into the rolls, *i.e.*, to use rolls whose diameters are slightly greater at the centre than the edges. For a given degree of camber the roll gap will be uniform for one value of rolling load. It is obvious, therefore, that some compromise

must be made in practice and it should be equally obvious that one essential item of instrumentation is the permanent installation of load cells.

In hot rolling, conditions for the production of sheet may differ widely from the production of strip, especially on a jobbing mill. In the latter case, considerable skill may be employed to obtain the best results : the roller can adjust the sequence of work to allow for the change of camber resulting from the changes in temperature of the rolls and, if rolling narrow work on a wide mill, may deliberately place the work in order to correct bad shape. It is usual to roll narrow materials while the rolls are cool and to change to wider materials as they warm up. And it is usual to make provision for roll heating prior to the commencement of rolling.

Modern strip-rolling mills usually work on a virtually continuous basis and it is essential to employ direct water cooling to prevent overheating of the work rolls. Four-high tandem mills are generally employed and the work may be drawn out of the furnace at the speed of entry into the first rolling stand. Theoretically, this leads to an identical temperature throughout the length of the bar at the first stand and to a very slight loss of temperature between stands. While this aspect is very desirable and should simplify the control of gauge, the complexities of such a mill are such as to throw the onus of gauge control on to the last stand.

The planetary mill deserves special mention in view of its revolutionary design. Practically all the work is carried out at the one stand and since there are about 20 small-diameter work rolls circulating round each back-up roll, direct water cooling of these is extremely effective and it is claimed that hot-rolled strip can readily be obtained from these mills at thicknesses of 0.064 in. to 0.12 in., where the maximum variation edge to edge and end to end of the coils is no more than $\pm$ 0.001 in.

In the main the sources of gauge variation other than those already mentioned are common to hot and cold rolling and will be dealt with under the heading of cold rolling.

With the exception of the hot Steckel reversing mill, it is clearly impossible to hot-roll long lengths of strip on a reversing mill, since heat loss is excessive unless the material can run to and from holding furnaces. The excessive temperature losses which do occur lead inevitably to gauge variation along the length of the hot-rolled strip.

It must be emphasized that it should be the aim of the hot roller to provide the cold roller with the most uniform material possible. Unfortunately, hot-rolled material is inevitably oxidized and must, therefore, be subjected to some intermediate treatment prior to cold rolling, and some change of gauge is inevitable whether cleaning be effected by pickling or mechanical means.

Cold Rolling

The major factors which combine to influence the gauge of metal obtained in cold rolling may now be considered. They may be listed as follows :—

(*a*) Roll deflexion ;
(*b*) Roll camber ;
(*c*) Roll flattening ;
(*d*) Temperature change in rolls ;
(*e*) Extension of mill housings ;
(*f*) Eccentricity of rolls ;
(*g*) Worn bearings ;
(*h*) Thickness variations of stock ;
(*i*) Friction and lubrication ;
(*j*) Speed effects ;
(*k*) Setting of roll gap.

In hot rolling, temperature effects are far more important than several of the factors which must now be considered, though all have an effect upon gauge whether the rolling be hot or cold.

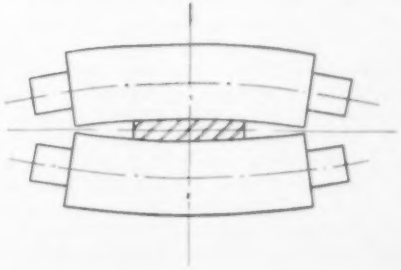
Roll Deflexion

Variation in gauge across the width of either sheet or strip is usually an embarrassment to the users of the metal and is most troublesome during forming operations due to displacement of variable quantities of material. This is particularly apparent during deep-drawing operations and is liable to cause ears or laps on the drawn components. Suppliers of sheet and strip are fully aware of the difficulties that this variation may cause, and take certain steps to minimize and, if possible, overcome this undesirable defect.

In the case of a two-high mill the rolls are rigidly supported at either end at the roll necks, while the parting load is uniformly distributed over the length of barrel in contact with the work, consequently some bending of the roll must occur. The amount will depend on :—

(*a*) The type and condition of the metal being rolled ;
(*b*) The width of the material being processed ;
(*c*) The percentage reduction per pass ;
(*d*) The diameter of the rolls ;

Fig. 4—Deflexion of parallel rolls under load



(*e*) The structure and physical condition of the rolls.

The effect of parallel rolls under load can be seen from the diagram (Fig. 4) and this obviously produces an undesirable cross-section on sheet or strip. The main contributory attempt to counteract roll deflexion is to provide the rolls with a predetermined shape; this is known as "camber."

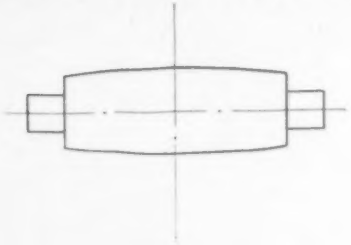


Fig. 5 (above).—Cambered roll

Fig. 6 (right).—Ideal effect for loaded cambered roll

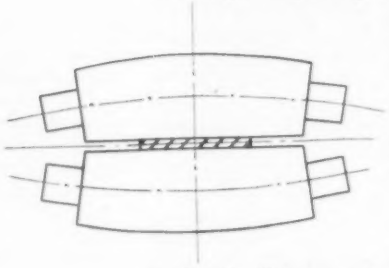
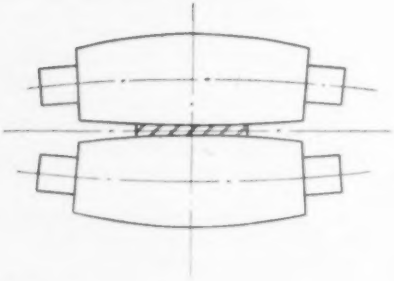


Fig. 7 (below).—Effect with excessive camber



Roll Camber

Roll camber is the shaping of the rolls to counteract roll deflexion, *i.e.*, the diameter of the centre of the roll is greater than that of the outside ends (Fig. 5). There is a specific camber for any one set of precise conditions. It is rare that the ideal condition can be achieved, but at least it is possible to obtain a good compromise. Camber may be used by the skilled roller to induce some lateral movement in the work in order to reduce edge to centre gauge variation whilst maintaining good shape. Fig. 6 shows the deflexion of the roll being ideally corrected by the camber.

Fig. 7 shows the effect of too much camber.

Roll Flattening

Elastic flattening of rolls takes place due to contact pressures between the rolls and material being passed through them, and between work rolls and backing up rolls. They will revert to their original shape when the load is disengaged, *i.e.*, when working material either leaves the rolls completely or moves along the circumference to a new arc of contact. Thus, roll flattening is a factor that can affect the gauge and will vary with the speed of rolling, camber, roll diameter, roll structure, type and condition of the alloy being rolled, entry thickness, parting load, the reduction taking place, the arc of contact between rolls and work, roll surface, lubrication of contact surfaces and several other effects.

Temperature Change in Rolls

When the temperature of the work rolls changes a corresponding change in roll diameter will occur. Unless the change is uniform there will also be a change in camber. The importance of the effect can be seen from the following example. Assume the coefficient of linear expansion of a work roll to be 12×10^{-6} per ° C., a temperature increase of 11° C. on a 15-in. diameter work roll will increase the radius by 0.001 in. This will occur on both rolls, thus reducing the roll gap by 0.002 in.

From this example, it can be seen that only moderate temperature changes on rolls and work could have a considerable effect on final gauge. It is essential to keep this temperature change to an absolute minimum, especially when rolling long lengths of strip at high speeds.

Extension of Mill Housings

When metal is fed into the rolls, the parting load on them is transferred to the bearing blocks and in turn to the bottom of the screw-down shafts and, consequently appears as a tension load on the mill frame. This will cause an elastic extension of the mill frame which again will tend to allow the rolls to open out a little in relation to each other. If due allowance is not made for this it can affect the gauge of sheet or strip.

Eccentricity of Rolls

This fault arises when the axes of the roll necks and roll barrels are not colinear, and should only arise due to faulty roll grinding practice. Clearly if the fault is present it will generate a cyclic variation in gauge.

Worn Bearings

When bearings become worn it is possible for the roll neck to seat (or ride) in slightly different positions depending upon the load and speed and efficiency of lubrication. The change of seating position may indeed be subject to oscillation. The result will be a change in roll gap and, therefore, in gauge. Whether the roll neck bearings are white metal, bronze, Tufnol, or, as in the majority of modern mills, roller bearings, first-class maintenance is essential.

Thickness Variation of Stock

It is essential that the stock for cold rolling should be as uniform in regard to thickness as possible. As rolling proceeds variations may tend to be decreased, but will invariably lead to a thickness variation in the finished sheet or strip. If the variation on the initial material is across the width, further reduction will cause edgewise curvature, as the thick side will elongate further than the thin side.

Friction and Lubrication

Friction plays an important part in rolling on a simple mill, enabling the rolls to draw the metal into the mill; nevertheless, the surfaces of the rolls and work are moving relatively to each other. The rolling pressures are very great and rolling lubricants are used to prevent pressure welding or pick-up occurring. The grade of lubricant used has a considerable effect on the surface appearance of the product. The frictional effect leads to the generation of heat and, consequent upon increase in rolling speeds, it became necessary to use the lubricant as a coolant also.

Clearly the roll bearings also require lubrication and, on certain types of mill (*e.g.*, Sendzimir), the requirements of the bearings may be of over-riding importance and dictate the choice of rolling lubricant.

Speed Effects

Variations in the degree of lubrication lead to gauge variations in several ways, especially on strip mills where speed changes are essential. As speeds are increased the roll temperature rises, the thickness of oil film, both on the work and on the bearing surfaces, will increase and, unless the roll gap is reset, the thickness of strip produced will be reduced on all of these counts.

Setting of Roll Gap

Setting of the roll gap is the roller's responsibility and, in the absence of automatic gauge control, he is also responsible for adjustment as may be necessary. Clearly when the only means of determining gauge was by the use of a hand micrometer, high rolling speeds were incompatible with the production of strip to close tolerances. Moreover, hand micrometers only permit measurement of the gauge at the edges of the material.

Continuous Gauges

Various methods of continuous gauging have been developed. The earliest types utilized a pair of rollers in direct contact with the top and bottom surfaces of the strip and, by electro-magnetic circuit, the gauge of the strip, or preferably the variation from a preset value, was displayed on a meter. This type of gauge was liable to mark the material.

Pneumatically-operated gauges have also been developed. No physical contact is necessary since they depend on the baffling action of a plate in close proximity to an orifice supplied with compressed air at a controlled pressure. Such gauges are in fairly common use and are reasonably reliable.

More recently, radiation gauges have been developed. Radioactive isotopes are used to provide an extremely stable radiation source which may be situated above the strip, while a detector is held below the strip. The proportion of the radiation which is absorbed or scattered by the strip is determined by the mass of metal lying between the source and the collector. These gauges have now reached a stage of development such that the indications of thickness may be relied upon to within ± 0.000025 in. over the range 0.005 in. to 0.025 in.

Automatic Gauge Control

With the advance in continuous gauging techniques it became possible for the operator to correct the roll-gap setting as soon as an error was detected. Nevertheless, as the result of the inevitable time delays and the fallibility of human agents, considerable quantities of off-gauge strip could still be produced so long as the operator remained in control of the screw-down mechanism. The development of automatic gauge control was the next logical step. Real progress in this direction had to wait until suitable thickness gauges, combining accuracy, high response rate and reliability, were developed and proven in combination with manual control. There are now several such gauges available. The development of electronic amplifiers and servo-mechanisms has made it possible to use the error signal from any such gauge to actuate the screw-down motors or to adjust the tensions in such a manner as to bring about a correction of the error.

One of the proven systems embodies a beta gauge and means to check itself (the gauge) against a

standard, and is arranged to operate *via* the screw-down motors. In order to eliminate continuous hunting two controls are provided, one setting the width of the dead zone within which no action is taken and the other setting the duration of pulses applied to the screw-down motors. The dead zone is usually set at about half the permissible tolerance, and so long as the error is sufficient to require correction a series of pulses will be transmitted to the screw-down motors, the frequency of pulses being automatically related to the speed of the mill. The effect of a correction pulse is felt at the gauging station before the next pulse is sent out.

The system outlined above provides for the production of very long coils of strip well within tolerance limits and yet eliminates the excessive wear of the mill screws which would result from continuous or over frequent corrections being applied. It has one very significant advantage in that the gauge of the strip is actually measured and consequently the errors due to the general heating up of the rolls are eliminated.

While this method of automatic gauge control is very satisfactory, it falls short of the ideal since the aim is to produce strip to very close tolerances rather than to a precise thickness.

Two alternative methods of automatic gauge control were proposed by Hessenberg and Sims[3], [4] in 1951. Both methods utilize the measurement of the roll-separating force :—

(*a*) To determine the gauge of the strip leaving the rolls ;

(*b*) To initiate the automatic control systems.

Since the whole of the mill structure may be regarded as a stiff spring, the actual instantaneous dimension of the roll gap will depend on the instantaneous measure of the roll separating force. It is permissible to neglect the elastic recovery of the strip as it leaves the mill, *i.e.*, to regard the roll gap and strip thickness as identical. Thus any increase in rolling load indicates a concurrent increase in strip thickness and vice versa.

The method first tried out is only suitable for cold rolling of strip under tension, and depends on the fact that the roll separating force is interdependent on tension. Any increase in the entry and exit tensions will reduce the rolling load and vice versa. Consequently, if, without recourse to resetting the screws, but solely by adjustment of these tensions, the roll separating force can be restored to an initial value measured when the gauge of strip being produced was correct, the resultant strip will be of correct gauge.

The output of the load measuring cells is compared with a pre-set reference voltage and the difference may be displayed as a measure of the instantaneous gauge error. The difference may also be amplified by electronic means and applied either to the decoiler and coiler motors of a single stand mill, or to the motors of the two adjacent stands of a tandem set-up, so as to vary the torque of these motors and so adjust both entry and exit tensions for the stand under consideration. The tension method has been developed commercially and is generally used on tandem mills.

The other method, originally known as the predetermined setting method, is often referred to as the screw-down control. In this case, the roll gap is reset as necessary.

Considering the mill as a stiff spring, the actual change in roll gap from a pre-set value must correspond to the change in roll-separating force, and the change in position of the screw-down gear necessary to restore the roll gap to an original value can be calculated. The output of the load cells may, therefore, be compared with the output of a potentiometer coupled to the screw-down gear to which is added a pre-setting device. The out of balance voltage will again be a measure of the instantaneous error in gauge and can be used after amplification to control the positioning of the screw-down gear. Alternatively, the roll closing force may be generated by hydraulic rams and the pressure supplied adjusted to eliminate the error signal. It should be noted that in this system any correction applied increases the departure of the rolling load from the value used when pre-setting the mill.

The screw-down method is applicable to hot rolling and cold rolling either of sheet or strip and is also frequently used at the present time. Some slight delay is inevitable since the alteration in screw-down position is a mechanical operation.

In the original form, both these methods of automatic gauge control were capable of dealing with those variations in gauge which have their origin in the dimensions and quality of the ingoing strip or in the frictional conditions within the roll gap. Thus two of the most troublesome sources of longitudinal gauge variation, namely variation in temperature and variation in speed during the starting and stopping periods in cold rolling, may be largely eliminated. On the other hand, in the original form certain sources of variation remained and in some instances became more troublesome. Among these were roll eccentricity and change in dimensions of the rolls due to temperature changes.

The two systems have now been married in what is known as the combined system[5]. In this case the tensions are used to obtain maximum response rate, and when the pre-set tension limits are exceeded screw-down adjustments are made along with synchronized tension adjustments to bring the tensions back to normal values. Furthermore, signals from a reliable beta gauge may also be introduced into the controller network in order to correct for slow drifts which may arise in the

amplifiers or from causes such as temperature changes of the rolls.

Conclusion

The authors have endeavoured, and hope that they have been successful in explaining the development of the rolling mill, continuous thickness measurement gauges and automatic gauge control, as a serious attempt to overcome the problems of bad shape and uneven gauge, and to satisfy the demands of the users and fabricators of sheet and strip metal.

While it can readily be seen that a great advance to these ends has already been made, particularly during the last 5 to 10 years, users' demands are becoming increasingly severe and critical, and with the technological advance at its present rate, both sides are being forced into continuously considering methods for improvement and progress.

Acknowledgements

The writers wish to express their thanks to the directors of Henry Wiggin and Co. Ltd., for permission to publish this paper and to colleagues for their helpful advice and assistance in the preparation thereof. Thanks are also due to the Post Office Research Station (Dollis Hill) for permission to reproduce a drawing of the Lord insert (Fig. 3).

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DISCUSSION

Mr. BAKER (Gillette Industries Ltd.) asked what gauging tolerance could be expected from the beta gauge under rolling conditions.

Mr. TOBIN said he would give his experience and hoped that others would also comment on the point as it would be appreciated that the length of coils produced were relatively small in his work compared with that of some of the steel workers in the audience.

Generally speaking, he had found that gauging to 0.0001 in. in rolling practice was about the best that could normally be expected because there were bound to be fluctuations of the gauge itself during rolling. Variations of between 0.00005 in. and 0.0001 in. could readily be detected during continuous strip rolling.

Mr. COOK (J. J. Habershon and Sons Ltd.) said he was puzzled by the explanation given in the preprint of the paper that the difference in behaviour of work rolls of various diameters when rolling thick and thin materials was due to internal friction.

Dr. B. B. HUNDY (Steel, Peach and Tozer) and Dr. J. F. WALLACE (Sheffield University) reinforced Mr. COOK's remarks. (The authors have amended the wording of the paragraph in question.)

Dr. E. MARKS (Richard Thomas and Baldwins Ltd.) said that the authors had suggested that in order to roll strip steel to 0.0002 in. thick, they were entirely dependent on the use of a high value of tension. Could high values of tension be obtained at this thickness ? He was referring to the use of the Lord mill.

Mr. TOBIN said that tensions used when rolling very thin material were of such magnitude as to approach the tensile strength of the material being rolled. Inevitably, when the strip was very thin the value of the tension was extremely critical and the risk of breakage great. It was, therefore, necessary to ensure that the edges of the strip were free from cracks, and this was done by shearing the strip prior to rolling. Strip 0.0002 in. to 0.0004 in. in thickness had been successfully produced in nickel, Ferry, Monel and various nickel-chromium alloys, including Nimonic 90.

Dr. WALLACE referred to the use of the beta gauge with a sensitivity of 0.000025 in. What was the good of this when the gauge control was obviously related to the profile ? This gauge was measuring only one point on the width of the strip. Referring to screwdown methods of control with tension it would be found that this gauge would indicate one value whereas the overall thickness of the strip might be entirely different.

Mr. TOBIN replied that the authors had themselves questioned this claim of accuracy, but they had been led to believe by the suppliers that they could expect this tolerance. The fact that such a gauge sensitivity was quoted in the paper did not necessarily mean that the strip would have this accuracy on thickness tolerance. The authors had made no claim, and he doubted whether any of the strip producers in the audience would claim to be able to achieve strip anywhere near that tolerance.

The advantage of most of these gauges which were coming into more prominent use was that it was not necessary to have a point contact on the material. Those with which he had experience covered an area usually of 24 to 30 sq. in., giving an average reading over that area. Instead of measuring directly along the edge or the centre of the strip and being led to believe that the measurement for the rest of the strip was the same, there was an average measurement over a reasonable area of strip. This was far better from the producers' point of view and presumably far better from the users' point of view, because there was less disagreement on what the actual gauge of the material would be.

Mr. HARTLEY said he was glad that Dr. Wallace had brought up the question of profile. One point

which the authors had wanted particularly to bring out in the paper was that to obtain good quality strip, uniform in gauge, not merely from end to end but also from edge to centre, it was very important that the starting stock should be right. Virtually nothing could be done to correct the profile once cold rolling had started.

Mr. COOK emphasized to users that, although gauges had now been produced which could reach these fantastic accuracies, it did not mean that strip would be received from the shops of the same accuracy. Some years ago he had been concerned with the more theoretical side of gauge control and now he was concerned with producing strip to meet customers' requirements. His personal view was that the existing methods of gauge control were too good for the producers. There was no point in developing them further, because they were already lagging far behind in achieving gauge standards, purely because raw material contained variations from end to end or across the width which overrode the accuracies which were achievable by existing gauge-control techniques.

On four-high mills his experience was that it was possible to roll to within plus or minus 0.00025 in. along the length fairly consistently. The problem arose from the fact that the customer was just as much interested in the gauge in the middle of a 6-in. strip as he was in the outside edge. Nothing could be done about that by screwdown methods. While it was possible to roll along the length to plus or minus 0.00025 in. with consistency, these tolerances could not be produced on 6-in. wide strip because of the gauge variation across the width.

Mr. SCHEY (British Aluminium Co. Ltd.) queried the statement on page 2 of the paper that in the Steckel mill the reduction was limited because of the limited load-bearing capacity of the strip pulled through the rolls. He had no experience of these mills, but simple theory suggested that if a mill was equipped with two driving coilers on both sides, it should be possible to use the decoiler for this purpose, and in that way it was possible to reduce the actual roll force and increase the reduction up to a point which was strictly limited only by the flattening of the rolls.

Mr. HARTLEY said that in the early stages of a tensile test the material stretched uniformly, but after a time local necking occurred followed by fracture. In the early stages of the test the work hardening which occurred enabled the material to accept the increasing load, but later the increase in work-hardening was insufficient to support an increase in load and, consequently, severe local deformation and ultimate fracture of the specimen occurred.

There was a great similarity in rolling on a Steckel mill and backpull wire drawing, since the rolls on this mill were not driven, and the material was tensioned on both sides of the mill. In backpull drawing of annealed wire, the die reaction might be nearly eliminated but the tension required to pull the wire through the die was greater than when no backpull was used, consequently this tension was nearer the breaking stress of the drawn wire. If the ingoing wire was already hard, the reduction in die reaction was proportionally much less due to backpull at the limit set by the breaking strength of the drawn wire.

These comments applied equally to the Steckel mill and in practice there was a very definite limit to the percentage reduction which could be achieved in one pass. When, however, the back-up rolls were driven, as in the C.M.P. mill, the reductions which could be safely achieved at one pass were much greater.

Dr. J. F. WALLACE asked for comments on the use of pre-stressing, *e.g.*, by inserting pieces of material between the chocks prior to screwing down, on gauge variation of strip. Assuming that the load originally imposed by the screwdown gear on the material between each pair of chocks was, say, 1,000 tons and the expected load on the mill was 2,000 tons, what effect would this have on gauge variation of the strip rolled also assuming that the ingoing material was not uniform and that the rolling load rose on occasions to, say, 2,200 tons?

Mr. HARTLEY replied (in writing) that the presence of material between the chocks permitted pre-stressing the frame of the mill by putting the inner halves of the chocks and the separating material into a state of compression. So long as the actual rolling load did not exceed the pre-stress value, there would be little change in the stress on the mill frame, since any further elastic stretching of the frame would relieve the compressive force upon the separators. When, however, the pre-stress load was significantly exceeded the presence of the separators would cease to affect the behaviour of the mill. Thus, to a point, gauge variation would be due almost solely to variation in bending and flattening of the rolls, and beyond this point would also involve variation due to elastic stretching of the frame.

Mr. S. CARLISLE (B.I.S.R.A.) said that this method of defining a gap between the roll chocks by putting the metal in and increasing the load to a value above the maximum roll load likely to be required would reduce the amount of gauge change which would result normally if the screws were not adjusted, but the amount of reduction depended upon the relationship between the elastic constant of the roll in relation to the elastic constant of the mill housing and roll system. A mill should be considered as an elastic system and it was necessary to know what the elastic constant was to set up a gauge control. Much work in this connexion had

(*Continued in page* 213)

Control of Thickness of Metal Sheet and Strip

(*Continued from page* 212)

been done by B.I.S.R.A. In many cases it had been observed that the magnitude of deformation for a given load of the roll and system was about half the total of the deformation of the system. By the method suggested it might be possible to reduce by about 50 per cent the magnitude of gauge changes resulting for a given gauge change in the ingoing material, but it would have a disadvantage by restricting the application of automatic gauge control by screw control, because any improvement would be entirely restricted by the fact that it would be necessary to adjust the relative position of the chocks.

Mr. MCWILLIAMS (Projectile and Engineering Co. Ltd.) asked when the users could expect to benefit from this control of gauge thickness by the manufacturers.

Mr. COOK commented that the benefit was already being experienced.

Mr. TOBIN said that this was a reasonable question. He referred Mr. McWilliams to the last five lines of the conclusion in the paper :—

" While it can readily be seen that a great advance to these ends has already been made, particularly during the last five to 10 years, users' demands are becoming increasingly severe and critical, and with the technological advance at its present rate, both sides are being forced into continuously considering methods for improvement and progress."

Certainly much of the strip which had been accepted in the past had not encouraged producers to move at a rate which might well have been possible, but present technological advance was keeping producers continuously alert. Customers were constantly requesting better-quality strip and there was a constant advance in the techniques being used. There was a gradual change in the design of mills. One company was in the process of installing automatic gauging throughout the plant. The strip coming off the plant was certainly better than it had ever been and research and development were taking place continuously to improve it still further.

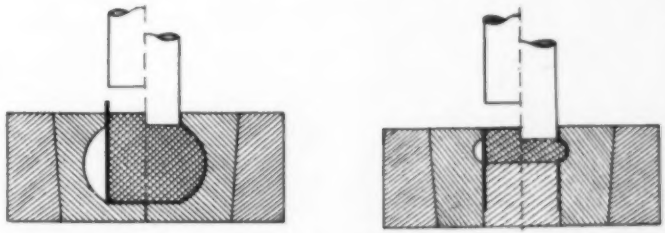
The gauges themselves were far in advance of any probability of getting the strip within the gauge limits, but at least these gauges let producers know what results they were achieving and showed them the target at which they must aim in their gradual improvement. There was also the question of load cells and electronic control, which were being developed and introduced into rolling mills. Obviously, these would have the direct effect of improving the quality of the strip.

Drawing Cups from Thin Metal Sheets

(*Continued from page* 184)

typical example of this process, Fig. 4*a* representing the cup before bulging and Fig. 5*a* after bulging. A disc with a guidepin (*d*) slides in a centre bore of the counter-punch (*c*). A rubber pad (*b*) with a Shore hardness of about 70 is placed between the disc and counter-punch (*c*). Under the pressure of punch (*a*), cup (*f*) is deformed to a shape given by the recess of the receiving block (*e*).

Such a process can be used for thin sheets of moderate hardness (especially light alloys) with high ductility and a wall thickness not exceeding 0.75 mm. The working pressure averages 210 kg. per sq. cm. ; the rubber pad should have a Shore hardness of about 70.



Figs. 6 *and* 7

Figs. 6 and 7 show two typical examples of bulging of circular shapes.

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NEW BRITISH DOUBLE-ACTION POWER PRESS

600-ton Machine for Production of Motor-Car Panels

A 600-TON double-action press has recently been constructed by Wilkins and Mitchell Ltd., Darlaston, for the Midland Radiator Co. (Birmingham) Ltd. The press, which will be used for the production of motor-car panels, is the first of a new series of double-action machines which will be manufactured by the company.

The general specification of the press, shown in Fig. 1, is : draw slide ; capacity 600 tons, suspension 4-rod, stroke 33 in., adjustment (motor) 18 in., tool area 90 in. (left to right) by 54 in. (front to back) : blankholder and slide ; capacity 400 tons, suspension 4-rod, stroke 22 in., adjustment (motor) 18 in., adjustment (hand) $\frac{1}{16}$ in. at each corner, tool area 108 in. (left to right) by 72 in. (front to back). The bolster is 108 in. (left to right) by 72 in. (front to back) and is 10 in. thick. The press operates at 10 strokes per min.

The frame is of unit construction, consisting of bed, columns and crown, aligned by keys and clamped by tie rods, the units being fabricated from rolled-steel plate, stress relieved and designed to ensure minimum deflections under operating conditions.

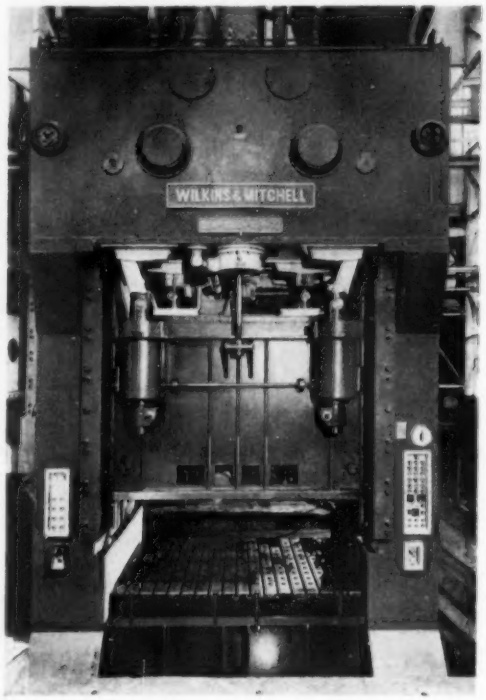


Fig. 1 (above).—General view of press

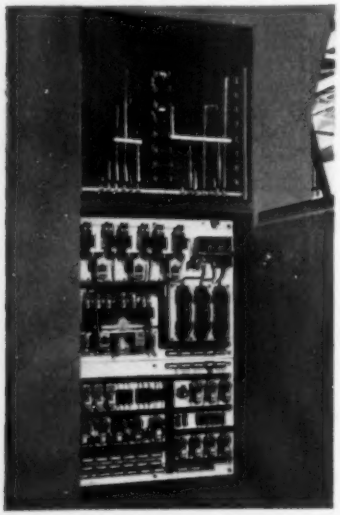


Fig. 2 (left).—Control equipment built into press frame

The tie rods are carbon-steel forgings, machined to take cartridge-type heating elements ; these are shrunk into place with sufficient preload to ensure that the " lift off point " for the frame is twice the rated capacity of the press.

Both draw and blankholder slides, which are of fabricated rolled-steel construction, are designed for maximum rigidity and minimum deflection, and are exceptionally deep with slideways of long length making for better guidance. All slideways are phosphor-bronze lined and provision is made for accurate setting of the blankholder. In each case the slide adjustment is motorized with an additional feature on the blankholder slide of $\frac{1}{16}$-in. individual hand adjustment at each corner.

Power transmission is effected from the clutch shaft by triple reduction gearing to the pin eccentrics, from which the connecting rods impart the draw-slide motion. A link mechanism from the eccentrics gives the required motion to the blankholder slide.

All high-speed shafts are mounted in anti-friction bearings and low-speed shafts, connecting rods, links, etc. are bronze bushed and individually

(*Continued in page* 218)

3

SHEET METAL DATA SHEET

Mechanical Presswork — 1

Compiled by J. W. Langton, M.B.E., B.Sc.(Lond.), M.I.Mech.E.

TYPES OF PRESSES

IN all mechanical presses there are three fundamentals (*a*) a base or block to carry the bottom tool, (*b*) a ram to carry the top tool, and (c) means of bringing ram and block together. Usually the main frame carries the block with provision for the ram to work in it. The power means of bringing the two together can be from hand, foot, or mechanical power, and these will be taken as headings for the various groups. It should be appreciated, however, that the terminology for the type descriptions is very loose, descriptions being taken from several of the press features.

Group One

HAND PRESSES

Common types—**Hand Lever Press** where ram is worked in the frame by hand levers. The most usual is toggle press. Motion here is to and from operator, or by side hand lever. In tonnages usually up to 3.

Hand Screw Press (Fly Press or Hand Press) (1)*

Here the ram is moved by the operation of a screw, which is turned by the operator through a handle or fly. Common types:

(*a*) **Standard or C Frame.**—Main dimensions—bed to guides—centre to back. Screw diameter.

(*b*) **Tall Type.**—A range with abnormal bed to guide dimensions (max. about 16 in.).

(*c*) **Deep Back.**—A range with abnormal centre to back dimensions (max. about 12 in.).

(*d*) **Double Sided.**—Frame Arch Type. Additional dimension, distance between sides.

(*e*) **Bar.**—The solid bed is omitted and provision is made to fit a bar on which the work may be supported. Mainly for work on cylinders which can pass over the bar.

(*f*) **Platen Presses.**—Where ram area is increased to have a platen, to give pressure over a wider area.

Most of the screw presses are selected dimensionally, but pressure exerted is directly related to screw diameter, very roughly—pressure exerted in tons is twice screw diameter. Pressure is increased by fitting ball weights to fly handle. These presses can be converted to air operation (1a).

Group Two

FOOT PRESSES

Here the ram is operated by levers connected to a treadle. Presses are used for light pressing operations where there is high virtue in having both hands free to feed and remove the work (2).

Bar Foot Presses can also be obtained.

Usually selected dimensionally—centre to back, bed to guides.

Group Three

POWER PRESSES

First Classifications

Single-acting Press is one with one ram or slide only. Far and away the most common type—so much so that the term "single acting" is often dropped (3).

Double-acting Press is one with two rams—one working inside the other. Used for drawing work, the outer ram carrying the blankholder—the inner the drawing punch (4).

Two Main Types.—*Cam* where outer ram is operated from cams on crankshaft. Usually C-frame. *Toggle*—where toggle levers operate outer ram (usually double-sided frame).

Triple-acting Press.—Double-acting press with third motion below press bed for embossing, etc., pressings during drawing.

Details of Single-acting Types

(*a*) **Definitions according to press frame.**

Open-fronted or C Frame

Upright:	Frame fixed—bed horizontal.
Inclinable:	Frame will swing so that bed is at angle up to 45 deg. about (5).

*Numbers refer to illustrations on page overleaf.

3 SHEET METAL DATA SHEET

Mechanical Presswork — 1 (Cont.)

Open backed: With opening through frame back to permit work to fall away.

End wheel: Crankshaft moving back to front of press—flywheel at end.

Horn press: Provision in frame for horn. Usually these presses are also arranged to have an adjustable table, which can be removed to permit work to be done on the horn.

Double-sided or Arch Frame—opening front to back.

Frame may be solid, *i.e.* one piece (up to about 150 tons) or built up from sections fastened together by tie bars.

(*b*) **Definitions according to transmission.**

Direct driven: Flywheel and clutch mounted on crankshaft.

Geared: Single geared—one pair of gears between flywheel and crankshaft (3). Double geared—two pairs. Twin geared—main gear on both ends of crankshaft.

(*c*) **Definitions by connexion to crank.**

With one connexion between ram and crankshaft—single crank: two connexions—double crank.

(*d*) **Definitions by actual type of work done.**

Special single acting presses are named simply by work they do, *i.e.* notching presses (6) (open-fronted presses with special attachment for notching) multiple presses (presses with multiple rams).

(*e*) **Definitions re stroke.**

Fixed stroke means that the throw by the crankshaft is constant.

Adjustable stroke—variable throw usually arranged by eccentric bushes in connexions.

Watch for common error—all presses usually have adjustment for *phase* of stroke—usually by split connexions. This does not affect the *amount* of the stroke as can be done in adjustable stroke presses.

(*f*) **Definitions by Feed.**

If a feed is fitted to a press it usually adds to its definition, as roll feed press (7), dial feed, etc. There are many types of feed which can be fitted to increase output, the most common being:

Roll Feeds which feeds the stock to the tools.

Single-roll Feed—one pair of rolls.

Double-roll-Feed—two pairs of rolls—one to feed, one to extract—tension kept across material (7).

General definitions—maximum width of stock to be fed and maximum amount of feed. Feed accuracy varies with quality of roll feed, but a good one with medium feed in the neighbourhood of 0.002 in.

Slide Feeds for feeding of stock, which is gripped between two metal surfaces and moved according to feed stroke. Many such on the market—variables in how the stock is gripped, and how it is moved. *In general* they tend to be a little more accurate than roll feeds.

Suction or Strip Feed.—Strip stock picked up from hopper and fed through tools automatically. Here feed is really integral with press.

Dial Feeds for feeding components in secondary operation work. Consists essentially of dial rotated by crank into which work is placed.

Other Feeds—Friction Dial—Magazine—Reciprocating, etc.

The fitting of a feed makes a very considerable difference to the outputs.

PRESS AUXILIARIES

Pressure Mediums

These are mounted below press bed to supply pressure to the tools, mainly in drawing and raising work. Can be of elementary form, pressure being supplied by springs or rubber buffers, or more elaborate forms of oil or air cushions. When fitting a cushion, usual to fit one 1/5 of press capacity.

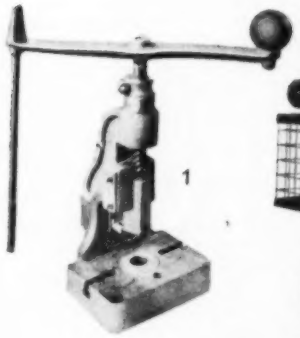
Cushions are mentioned here because they can be an integral part of the press, to be considered along with type selection.

Operational Guards

Where the operator is required to feed presswork by hand to the tools, it is essential to fit a special operators guard, so that the press cannot be worked unless both hands are out of danger. These guards are specially made by various specialists, and their need should be considered at the time of press selection, as they are not usually immediately available (8).

SHEET METAL DATA SHEET 3

Mechanical Presswork—1 (Cont.)



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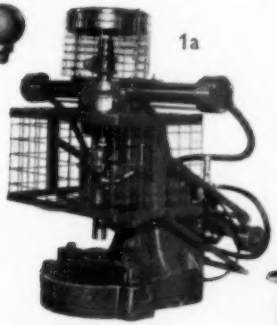

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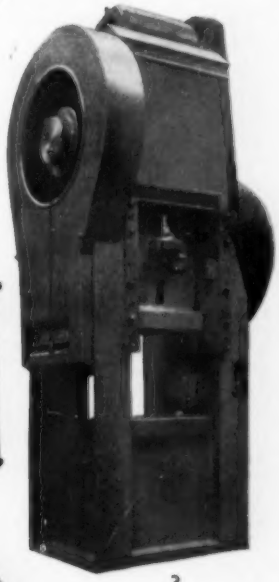

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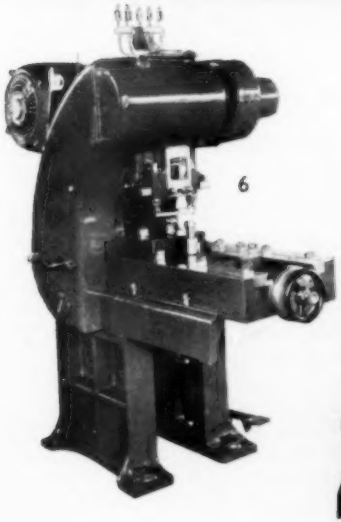

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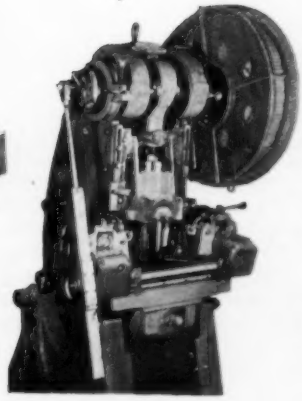

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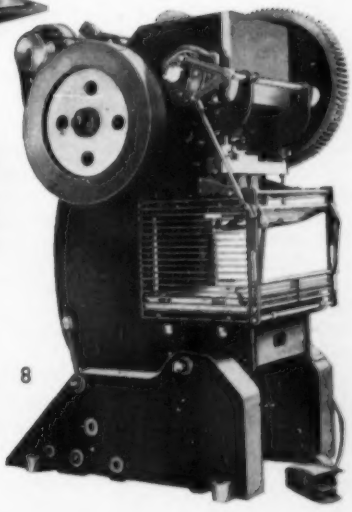


8

EXPANSION OF ALUMINIUM ALLOY PRODUCTION

THE largest rolling mill of its type in Western Europe has been ordered by James Booth Aluminium Ltd., as the first part of its £5 million re-equipment and expansion programme. It is expected to be in operation in the company's Kitts Green Works, Birmingham, during 1961.

The mechanical side of the new plant, which will cost approximately £1½ million, exclusive of electrics, services and foundations, is designed to roll aluminium and Duralumin slab ingots weighing up to 6 tons, for the production of plate, sheet and strip. Included in the plant is a reversing 4-high hot mill 148 in. wide which will roll plates to a width of up to 144 in. It will also break down such slab ingots into strip, which will be finished-rolled in a single mill stand in the runout of the plate mill. This single mill stand will be replaced eventually by a 3-stand tandem mill.

The main item of the installation is the 4-high mill stand having work rolls of 38 in. dia. and 148 in. barrel length, the back-up rolls having a diameter of 60 in. The casting of each mill housing has a weight of 175 tons. Other main items are a heavy vertical edging mill, a shear to cut plates up to 4 in. thick, extensive roller tables and manipulators, all designed for the efficient handling of high-quality aluminium alloys.

The design and manufacture of all mechanical equipment of the plant has been entrusted to the Loewy Engineering Co. Ltd., Bournemouth.

Furthermore, a modern cold mill will be installed for the precision rolling of light-alloy strips with a width of up to 64 in. having a gauge of down to 0.012 in. This mill, of the reversing 4-high type, has rolls of 16½ in. and 44 in. by 72 in. and is fitted with all auxiliary equipment of the most advanced design. The mechanical parts of this mill will also be completely furnished by the Loewy Engineering Co. Ltd.

This is the first stage in the major development programme, it is stated by Mr. W. H. Vaughton, managing director, James Booth Aluminium Ltd., which is being carried out by a newly-formed team of specialized engineers under the direction of Mr. D. H. G. Clarke, M.A., A.M.I.Mech.E., engineering director of the company.

As well as providing much larger sizes of aluminium-alloy plate, particularly to meet the growing demands of the shipbuilding, chemical, aircraft and atomic-energy industries, the new plant will greatly augment the production capacity for all flat-rolled products.

Contracts for further equipment, which will make the Kitts Green Works one of the most up-to-date in Western Europe, will be placed shortly.

"Plastic-Coated Steel Sheet and Strip"

IN the paper by W. N. Jenkins, B.Sc., A.M.I.E.E. published in the February, 1960, issue, the buildings shown in Figs. 3 and 3a have *coloured* infill panels and are shown as representing the type of construction to which factory-made infill panels using plastic-coated steel could be applied. The illustrations are acknowledged to Reginald H. Gallannaugh.

New British Double-action Power Press

(*Continued from page* 214)

lubricated. Gears and links are of high-quality steel castings, shafts and pinions of alloy steel, eccentrics and eccentric pinions are straight spur, all other transmission gears being double helical.

The clutch is of the pneumatically-operated, low-inertia insert type, designed for easy maintenance, and the brake is of similar design but spring applied. The removal of the inserts requires a minimum of breakdown time, and a combination of large friction surfaces and adequate ventilation ensures cool running.

The heavy flywheel on anti-friction bearings is quill mounted, thereby eliminating high bending stresses on the shaft and ensuring true running.

The draw and blankholder slides are individually counterbalanced by pneumatic cylinders with ample-capacity surge tanks, the controls of which are mounted in the column and are adjustable from floor level. The size of the balance cylinders ensures adequate allowance for tools.

The centralized, full-flow, circulating pressure lubricating system ensures a measured supply of oil to each bearing and the system is protected by limit switches interlocked in the press control circuit to guard against failure. Slideways are grease-lubricated by a manually operated centralized system.

All electrical gear is built in to the press columns (Fig. 2) and consists of all motor starters and control gear, including an infinitely adjustable multi-cam rotary limit switch. A setter's panel is mounted at the front of the press and operator's plug-in push button stations are available at each corner. Solenoid-operated auxiliary pneumatic circuits are fitted, together with sequence-timed rotary limit switches, and pneumatic and electric take-off points are incorporated for hand tools, etc.

Two-speed clutch units can be incorporated in the press drive if required, and cushion equipment, overload devices, etc., can be incorporated to suit special requirements.

SHEET METAL NEWS

FEATURING EVENTS AND PERSONALITIES IN THE INDUSTRY

FIRST ALL-BRITISH EXHIBITION IN U.S.A. TO BE HELD IN NEW YORK

Her Majesty The Queen and President Eisenhower, Joint Patrons

An aerial view of the Coliseum, New York, in which the British Exhibition will be held

HER MAJESTY THE QUEEN has graciously consented to lend her patronage to the first all-British Exhibition to be held in New York this year, and the President of the United States of America has willingly agreed to serve as co-patron with the Queen.

British Overseas Fairs Ltd., organizers of the British Exhibition which will be held from June 10 to 26, also announce that they have concluded arrangements, with the approval of both the British and U.S. Governments, for the holding of a British Military Tournament and Tattoo in New York from June 18 to July 4.

Progress of Plans for the British Exhibition

The Exhibition will occupy the whole of the Coliseum. This magnificently equipped new exhibition building (shown above) is the recognized centre for exhibitions and trade fairs in New York and was the scene last June of the U.S.S.R. Exhibition, which occupied just over two of the four floors.

The biggest single exhibit will be that of the British Government, which is being executed for the Board of Trade by the Central Office of Information. It will be on the first (*i.e.* ground) floor and will be the first exhibit to be seen by visitors to the Exhibition. It will use some entirely new display techniques to emphasize Britain's position in the modern world and to show that she is in the forefront of modern scientific and technological developments. This will be followed by a display of some of British Industry's most outstanding recent achievements in engineering and industrial processes, put on jointly by the organizers and the Board of Trade.

Surrounding this display will be a number of striking prestige exhibits organized by the following: Iron and Steel Industry; Shipbuilding Industry; British Broadcasting Corporation; Royal Mint; London Clearing Bankers; Port of London Authority; British Travel and Holidays Association (together with BOAC and BEA).

For the display by the steel industry it has been determined that it should portray the industry as vigorous and progressive, keeping abreast with the newest developments in the steel centres of the world.

The keynote of the show will be the high quality of British steel, arrived at through excellent craftsmanship—based on long-standing tradition—and produced by efficient, modern plant.

The exhibits to be shown in New York have been selected in such a way as to follow the basic brief, and at the same time to be of the

(*Continued in page 220*)

UNITED STEELS MOVE TO NEW HEADQUARTERS

THE head office of The United Steel Companies Ltd., has been transferred from its existing premises in Westbourne Road to new headquarters at The Mount, Broomhill, Sheffield, 10, a journey of about 100 yards. Here, there is office accommodation for a staff of approximately 150 people, some of whom will be housed in The Mount itself, a 126-year-old building which has undergone extensive internal reconstruction, while others will be accommodated in an entirely new three-storey block and interconnecting wing which have been built behind the main building.

It was in 1834 that William Flockton, a well-known Sheffield architect, designed The Mount as a block of eight private houses sharing a common, pillared facade in the classical style. Flockton also designed the nearby King Edward VII Grammar School, formerly the Wesley College, employing a similar style.

In general, it has been the intention of the architects to preserve the original character of the old building; its facade is in fact scheduled as being of historic interest. In addition to a number of private offices, it contains a well-equipped kitchen on the second floor, serving three staff dining rooms.

The interconnecting wing which, like the new block, has been designed to harmonize with the rear elevation of The Mount, contains lifts, conference rooms and other facilities.

Special features of the new building include a spacious printing department, in which much of the general printing required by the company and its branches will be undertaken, and a mechanized accounts department. The latter incorporates an I.C.T. 1202 electronic computer, which has been acquired to further the knowledge and application of new techniques to mechanized accounting.

At the front of The Mount is an underground car park with accommodation for about 60 staff and visitors' cars. Linked with this car park is a hexagonal building which incorporates workshops, a wash-down bay and parking space for company cars. It is intended to lay out a bowling green and flower beds over the car park in order to maintain the amenities of a largely residential neighbourhood.

British Exhibition in New York

(*Continued from page* 219)

greatest possible interest to the American public—layman and expert alike.

In order to achieve this, the available sources dealing with the American market have been explored, the export position studied, and the potentialities of the market assessed as accurately as possible.

Also on the ground floor will be shown some of the G.P.O.'s unique collection of stamps, which they have lent to the B.O.F. for the Exhibition, including some of the original Penny Blacks, the first stamps ever to be used anywhere in the world. There will also be a section to show the opportunities for U.S. investment in the U.K., in which the Development Councils for Scotland, Northern Ireland, and Wales will take part, and a Central Information Bureau with separate enquiry counters staffed by the Board of Trade, the British Information Services in the U.S.A., the Dollar Exports Council, the Federation of British Industries and the British-American Chamber of Commerce.

The main features on the second floor will be a large specially decorated area (60 ft. high, 130 ft. long and 110 ft. wide) devoted to the "cream" of British top-quality consumer goods, and alongside it a series of furnished rooms, both contemporary and traditional, in which some of our most beautiful furniture and furnishing fabrics, carpets, china, glass, cutlery, sports goods and other consumer products will be shown. Also on this floor will be radio, TV and electronic equipment, and a wide variety of engineering goods.

The third floor will house a magnificent display of British machinery and engineering products of all kinds. Most of the great names of British engineering will be represented. The British Motor Show, which will also be on this floor, will be the biggest single industrial display in the Exhibition. It is the first time that the British automobile industry has shown a full range of commercial vehicles, both light and heavy, in the United States.

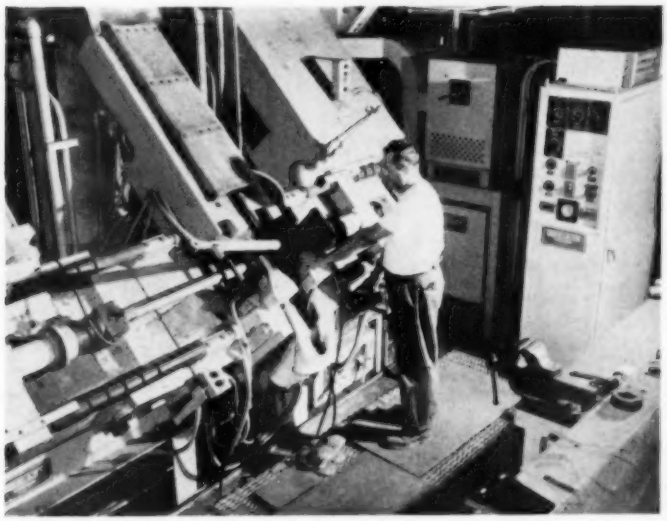
The atmosphere of the fourth floor will be quite different. An English inn, organized by the Brewers' Society and staffed in traditional way by English barmaids, will invite the American visitor to enjoy true British hospitality. The Scotch Whisky Association will show the skill which goes into making their famous product. A speciality grocery store will show—and sell retail—the high-grade British foodstuffs and beverages which have become increasingly popular in North America in recent years. Other shops will sell quality goods as souvenirs or gifts and there will be a special shop for sales of British periodicals, including British trade and technical journals. Additional features being planned for this floor are an English garden, a cinema for showing filmed British television programmes and documentary films, and a series of cartoons, selected by *Punch* and the *New Yorker*, to show "How we Laugh Together."

Organization

The overall planning of the Exhibition is in the hands of an Executive Committee as follows: The Rt. Hon. Lord Rootes, G.B.E. (chairman of the Dollar Exports Council); Mr. W. H. McFadzean (president of the Federation of British Industries); Sir Hugh Stephenson, K.C.M.G., C.I.E., C.V.O., O.B.E. (H.M. Consul-General in New York); Mr. Peter Garran C.M.G. (Commercial Minister, British Embassy, Washington); Sir Norman Kipping, J.P. (Director-General of the Federation of British Industries and Chairman of British Overseas Fairs Ltd); Sir Francis Evans, G.B.E., K.C.M.G. (B.O.F. Liaison Officer for Supporting Programmes); Sir Alexander Brackenridge, K.B.E., M.C. (chairman, Exhibition Liaison Committee in New York); Mr. W. P. N. Edwards, C.B.E. (managing director of British Overseas Fairs Ltd.).

PRIME MINISTER CHIEF GUEST AT INSTITUTE OF METALS DINNER

THE Prime Minister (The Rt. Hon. Harold Macmillan, M.P.) has accepted an invitation to be the principal guest and speaker at the Annual Dinner of The Institute of Metals, which is to be held in the Great Room, Grosvenor House, London, W.1, on March 31, 1960. The United States Ambassador has accepted to reply to the toast of "The Guests."



FLASH-BUTT WELDING ARRESTER HOOKS

THE Sciaky BMW 4 (500-kVA) flash-butt welder seen in the picture above is fabricating the V-shaped arrester hook for the Skyray carrier-based aircraft. Detailed tests applied after welding subject the hook to 300,000 lb. per weld in its heat-treated condition. Flash-butt welding used in this instance where the tubes and forged fittings are heated to a white hot plasticity prior to the butting force being applied, results in higher strengths than is normally attainable by fusion welding. The arrester hook is designed to withstand the tremendous shock that occurs when the aircraft, weighing nearly eight tons, "lands on" at high speed.

New Marketing Arrangements for Cutting Tools

THE manufacture and marketing in the United Kingdom of Surform and Surcut tools has now been transferred from Simmonds Aerocessories Ltd. to Firth Cleveland Tools Ltd. Both companies are members of the Firth Cleveland Group. The Surform and Surcut Home Sales Office will remain at Stornoway House, Cleveland Row, London, S.W.1.

Export sales continue to be handled from Stornoway House by Simmonds Aerocessories Ltd. as selling agents for Firth Cleveland Tools Ltd., and distribution in Sweden, Denmark, Holland, Belgium, Germany and Italy continues under the control of Simmonds Aerocessories' subsidiaries in those countries. Other local agencies remain unaltered. Simmonds Aerocessories Pty. Ltd. continue to manufacture Surform and Surcut in Australia.

Stenor Ltd. and British Lead Mills Ltd., both members of the Firth Cleveland Group, continue as selling agents to the garage trade and building industry respectively. They will also act as agents of Firth Cleveland Tools Ltd.

Press Manufacturers Celebrate 40th Anniversary

MR. A. GRAHAM DOWDING, chairman and joint managing director of Dowding and Doll Ltd., machine-tool manufacturers, recently received two presentations to mark the 40th anniversary of his founding of the firm. One, from the staff of "D. & D." was a stereophonic radiogram and the other, from his co-directors of the Dowding group of companies (which includes Dowding and Doll Ltd., Injection Moulders Ltd., Plastic Tool Co. Ltd. and Wade Engineering Ltd.), a pair of hand-pierced silver dishes.

The company have secured a further order, valued at £115,000, from the U.S.S.R. for 20 British Wiedemann turret punch presses. Model RA.41P, with pantograph table and depressible stylus for rapid short run piercing operations.

CHANGE OF TELEPHONE NUMBER

THE telephone number of Electropol Processing Ltd., Trading Estate, Farnham, Surrey, has been changed to Farnham 3355.

£10 MILLION STEEL MELTING SCHEME WILL TAKE FIVE YEARS TO COMPLETE

STEEL, PEECH AND TOZER, of Rotherham, a branch of The United Steel Companies Ltd., are to spend £10 million on the replacement of all their existing open-hearth steel melting furnaces by six electric arc furnaces of 110 tons capacity each. When completed this will be the largest electric steelmaking plant in the world with an annual capacity of 1,350,000 ingot tons of steel. It is also the largest single development scheme in the branch's 80-year history.

There are at present 21 open-hearth furnaces at Steel, Peech and Tozer—14 at Templeborough and seven at Rotherham—producing approximately 1,000,000 ingot tons of steel per year. The existing Templeborough melting shop is to be adapted to house the new electric furnaces. This will mean demolition of 14 120-ft. high chimneys which have been a local landmark. The Rotherham melting shop will be demolished.

Initially, four electric furnaces of the swing-roof type will be installed, and it is planned to have the first of these in commission by January, 1963. In order to make a start on the plant, the first two open-hearth furnaces at Templeborough will close down in two years' time, to be followed by others as the scheme progresses.

Arrangements have already been made to maintain the existing level of steel production during the changover by fitting double oil burners to some of the furnaces and converting other to "all-basic" refractory linings.

No order has yet been placed for the supply of the electric furnaces, but almost everything apart from the electrical equipment will be manufactured by Distington Engineering Co., Ltd., a United Steel subsidiary.

£2 MILLION SCHEMES FOR NEW STAINLESS-STEEL PLANT

WORK on £2 million schemes to expand the production capacity for stainless steel is being undertaken by Samuel Fox and Co. Ltd., a subsidiary of The United Steel Companies Ltd. Pioneers of large arc furnaces in this country, Samuel Fox are regularly making stainless in their 70- and 80-ton furnaces and production at Stocksbridge is over 1,000 tons a week.

The increased demand for stainless-steel flat products has necessitated further expansion of rolling capacity. Recently, Samuel Fox announced a £1 million project to modernize their Stocksbridge hot mill which will enable them to produce sheets and plates up to ¼ in. thick and 6 ft. wide by the middle of this year.

The cold mill is already capable of rolling 6-ft. wide sheets as the result of a carefully planned engineering operation during the summer. In the two weeks when production stopped for the works' summer holiday, this mill was completely rebuilt and widened from 42 in. to 84 in.

Work is to begin shortly on a scheme at Shepcote Lane Rolling Mills Ltd. (in which Samuel Fox have a one-third interest), to expand the production of wide stainless steel coils from 450 to 800 tons per week. Additions to the plant will consist of a second 42-in. Sendzimir cold mill and a fourth softening and descaling line, with extensions and modifications to existing ancillary plant, an extra coil build-up line, and a new furnace for softening ferritic steels.

Fork Trucks for Steel Stores

THE Steel Company of Wales have ordered Yale Series 51 8,000-lb. capacity fork-lift trucks for use in the re-organization of their main engineering spares stores at Ffrwdwyllt and Abbey. When completed, the stores will hold 60,000 different stock items valued at about £4 million. More trucks will be required as the stores become fully palletized.

The trucks are fitted with a side shift attachment, side, tail and spot lights, very high capacity batteries, canopy guards and discharge indicators.

Gauge and Toolmakers' Association Trade Luncheon

THE next trade luncheon to be organized by the Gauge and Tool Makers' Association will be held on Thursday, March 31, 1960, at the Savoy Hotel, London.

The Guest of Honour and Chief Speaker on this occasion will be the Parliamentary Secretary to the Board of Trade, Mr. John Rodgers, M.P. Present at the luncheon as Distinguished Guests of the Association will be a number of leading personalities in industry and Her Majesty's Government.

IMPORTANT ROLLING MILL ORDERS FROM AUSTRALIA

ORDERS worth nearly £700,000 for electrical equipment for Australian rolling mills have been obtained by A.E.I. Heavy Plant Division, Rugby, from Australian Electrical Industries Pty. Ltd.

The largest order is for drives for a new 5-stand tandem cold-strip mill which will roll wide strip at a maximum speed of 5,000 ft. per min. Motors with a total output of 20,750 h.p. will drive the mill and its tension reel, and the generators supplying direct current to the motors will be driven by two 10,000-h.p., 750-r.p.m. synchronous motors. Stand 1 will be driven by a single-unit 2,000-h.p. motor; stands 2, 3 and 4 each by a double-unit 4,000-h.p. motor; stand 5 by a triple-unit 5,500-h.p. motor; and the tension reel by a triple-unit 1,250-h.p. motor. Most of the control equipment for this mill will be manufactured in Australia to suit the control scheme designed by Heavy Plant Division engineers, but "Magnestats" (magnetic amplifiers) supervisory control panel, high-speed circuit breakers, and rheostats are being supplied from Britain.

B.W.R.A. New Address

The address of the London Office of British Welding Research Association is now 19, Fitzroy Square, London, W.1. Telephone: EUSton 9595/6. Telegrams: Weldaserch, Wesdo, London.

MERGER OF BISRA INFORMATION AND DEVELOPMENT SECTIONS

MISS I. M. Slade, BISRA's Information Officer for many years, has relinquished that post to take on consulting duties in the Association's Operational Research Department at the Battersea Laboratories. She will be closely concerned with ergonomic studies, especially in connection with problems involving safety and protective clothing, a field in which she has for long been an authority.

Mr. L. W. Stevens-Wilson, formerly Head of the Development and Steel User Section, has accordingly taken over new responsibilities. The distribution of information, the handling of inquiries, and the development and exploitation of the results of research, all of which are related, have been combined into a single unit. This will be called Development and Information Services, with Mr. Stevens-Wilson as head.

Gas Carburizing for the Motor Industry

WILD-BARFIELD Electric Furnaces Ltd., Watford, Herts, announce that orders have recently been received from The Rover Co. Ltd., for gas carburizing furnaces having useful work space dimensions 16 in. dia. by 32 in. deep, and from Leyland Motors Ltd., for equipment with a capacity 24 in. dia. by 46 in. deep. All these furnaces will employ "Carbodrip" as the gas carburizing medium in the drip feed method.

NEW HOT STRIP MILL FOR RICHARD THOMAS AND BALDWINS

THE order for the building of the 68-in. wide hot-strip mill for the new Spencer Works, Newport, Mon., of Richard Thomas and Baldwins Ltd., has been placed with Davy and United Engineering Company Ltd., Sheffield. The value of the contract exceeds £4 million.

The new mill will go into production in October, 1961, and will have an initial output of about a million tons of steel strip a year, but is being designed for an eventual output of around three million tons a year.

Davy-United will collaborate on the project with their American associates, United Engineering and Foundry Company, Pittsburgh, who are to build the slabbing mill and most of the cold-rolling plant for the Spencer Works.

HEATING VITREOUS-ENAMEL FUSING FURNACES

SINCE the development of the Incandescent Jetube radiant heating element for use in vitreous-enamel fusing furnaces was referred to last year, two prototype furnaces using specially designed Jetubes have been built and tested by the Development Division of the Incandescent Heat Co. Ltd.

Now the first batch furnace using this system has been built for an important vitreous enamelling works. A continuous split crown furnace, also heated by Jetubes, has just been commissioned at the works of Smart and Brown Ltd., Spennymoor, Co. Durham.

The Jetube radiant element (which may be gas or oil-fired) is claimed to give flexibility of operation, and allows the use of a highly insulated furnace structure with low thermal storage. Consequently fuel consumption is low, and output is greatly increased. Jetubes have already gained wide acceptance in industry as heating elements in batch and continuous furnaces for carburizing, hardening, annealing and stress-relieving.

NEW STEEL PROJECT FOR NIGERIA?

A BIG European steel organization—unnamed—is said to have approached the Federal Government of Nigeria to consider a possible basis for participation in a £500,000 steel mill project, states a Barclays Bank D.C.O. message from Lagos.

The project is for the production of reinforced steel rods from domestic ferrous scrap, which is at present being exported.

CAR FACTORY EXTENSION

FARMER BROTHERS (SHIFNAL) LTD., of Shifnal, Shropshire, a company in the Metal Industries Group, has secured a contract for the design, fabrication, erection and sheeting of new factory buildings for Jensen Motors of West Bromwich. The main contractors are Neenan (Contractors) Ltd. of West Bromwich. The new buildings will provide Jensens with an additional 100,000 sq. ft. of floor space.

British Agency for Continental Machine Tools

EXCLUSIVE distributors in the U.K. for the range of Zerbst heavy-duty facing and short bed lathes are Elgar Machine Tool Co. Ltd., 172-178, Victoria Road, Acton, London, W.3.

BIRMINGHAM ALUMINIUM STOCKHOLDERS MOVE TO NEW PREMISES

ONE of Britain's leading aluminium stockholders, Aston Aluminium Warehouse Co. Ltd., of Wheeler Street, Birmingham, 19, has, for the third time, moved to extensive new accommodation, this time in Clement Street, Birmingham.

The new building is constructed wherever possible with the use of aluminium. The roof, window frames, curtain walling, etc., are made in light alloy, the curtain walling, window frames and fittings having been anodized in some cases in natural colour, and in others dyed. The spacious well-planned warehouse and adjoining departments have all been designed solely for the storage and re-sale of aluminium. The warehouse is heated by oil, in order to maintain an even temperature, and to overcome temperature changes and consequent condensation. The offices occupy two floors and have floor heating thermostatically controlled.

Rapid Growth Since 1949

The rapid growth of the company since its formation in 1949 indicates the essential need for the metal stockholder specializing in aluminium and aluminium alloys, particularly when a prompt delivery service can be offered.

An essential feature of a specialist warehouse is to pay careful attention to probable new outlets for the metal. In recent months there has been a growing interest in the use of aluminium alloys in commercial transport and in the building industry. New designs for lorry bodies calling for special sections in light alloy have become popular. The company, to meet this need, has set up a separate organization—Alloy Transport Sections Ltd.—first to meet from stock supplies of special sections, plate and ancilliaries for the lorry body builder; second to supply a completely broken-down kit and finally for quick assembly of light-alloy lorry bodies on the spot.

For the building trade, Aston Aluminium Warehouse Co. Ltd. carry stocks of many special items with aluminium-alloy hook bolts, nails, etc., and provide also a service for bending and shaping sheet for tingles, gutterings, cappings and flashing.

OBITUARY

Lemner: Among the passengers in the air disaster in Turkey on January 19 was Mr. Rune Lemner, manager of the marketing department of Atlas Copco AB, Stockholm.

Mr. Lemner flew from Stockholm on the morning of January 19 to make a survey of the sales activities of the Atlas Copco organization throughout the Middle East with a view to further expansion of the company's activities. This was to have been his second long-distance business tour since his appointment as marketing manager in September, when he succeeded Mr. Olof Nibell.

Born in Stockholm on May 16, 1918, Mr. Lemner joined the Atlas company in 1943 as a sales engineer. In July, 1945, he became sales service engineer in Buenos Aires. A transfer to the group's Peruvian company followed in September, 1950, and he was appointed managing director of that company in 1953.

His services in South America did much to consolidate the interests of the Atlas Copco organization in the Latin American market.

He leaves a widow and three small daughters.

CHANGES IN MARKETING ARRANGEMENTS FOR ELECTRICAL SHEET AND STRIP

RICHARD Thomas and Baldwins Ltd. announce that all sales of electrical sheet and strip manufactured at their Midland Section will be handled by Richard Thomas and Baldwins (Sales) Ltd. For this purpose the present Midland Section sales department for electrical sheet and strip will be transferred to Richard Thomas and Baldwins (Sales) Ltd., but will continue to operate from Wilden, Stourport-on-Severn.

Mr. P. M. J. Boulasse has been appointed manager of the department and will be situated at the head office of Richard Thomas and Baldwins (Sales) Ltd., at 47, Park Street, London, W.1.

Mr. G. F. Astle and Mr. R. G. Martindale, M.Sc., M.I.E.E., have been appointed joint sales managers of the department and both officials will be situated at Wilden to which office all correspondence concerning sales matters should continue to be addressed.

Aluminium Logging Flume for Sweden

A LOGGING flume of welded aluminium sheet supported on a steel and concrete framework, about 4 miles long and with a capacity of 25,000 logs per hour, was completed and taken into use last summer at the 375-MW Stornorrfors power plant, which is Sweden's largest.

The water-conveying part of the flume is considered to be completely maintenance-free. The construction design and model testing were carried out by the Swedish State Power Board, and the sheet metal was delivered by AB Svenska Metallverken, Sweden's largest enterprise in the non-ferrous metal field.

The flume consists of 983 elements, 20 ft. long, composed of the aluminium segment and the steel framework. The segments have been welded together from a series of five aluminium sheets, 3 mm. thick, each set weighing 400 lb. The framework is composed of lengthwise supporting box-girders resting, in their turn, on steel sections anchored to ground sills of concrete.

The gradient of the flume, at 10 deg., is practically even over the entire course, and it passes on top of a blast-stone bank close to the river. When building the flume a specially designed erecting winch was used, which travelled on the box-girders as on rails. An average of 10 units per day were assembled, making it possible to perform the entire building in little over three months.

A certain amount of prefabrication at the Stornorrfors power station facilitated rapid erection. The aluminium segments and framework were bored and screwed together at this site, whereupon the assembled sections were transported to the mounting stations in crates holding five at a time. A rubber asphalt compound, "Tiger Rubber" was used to seal the aluminium and steel parts together, whereas profiled synthetic-rubber plating joined the overlapping aluminium segments to each other.

IDEAL HOMES AT OLYMPIA

TODAY, March 1, sees the opening of the "Daily Mail" Ideal Home Exhibition at Olympia, London. Featured will be the story of the development of the Post Office, which not only is an integral part of modern life, but also through its various departments, carries out important and fundamental research work on a wide range of subjects.

PLATE FINISHING LINE FOR JAPANESE STEEL MILL

A NEW heavy plate mill is being installed by the Kawasaki Steel Corporation, Chiba/Japan. The plant is scheduled to go into production during the first half of 1961. Schloemann Aktiengesellschaft, Dusseldorf, are supplying the entire finishing-line equipment beyond a roll stand having a 165½ in. barrel length. The equipment includes roller tables, cooling beds, two hot levellers, a rotary trimming shear, a rotary slitting shear, two rocking shears and conveying equipment.

EXCHANGING ALUMINIUM FOR MAGNESIUM

THE signing of an agreement with the Dow Chemical Co. of Midland, Michigan, covering the exchange of aluminium for magnesium was concluded recently for Aluminium Ltd. by its subsidiary, Magnesium Co. of Canada Ltd. It will run to 1971.

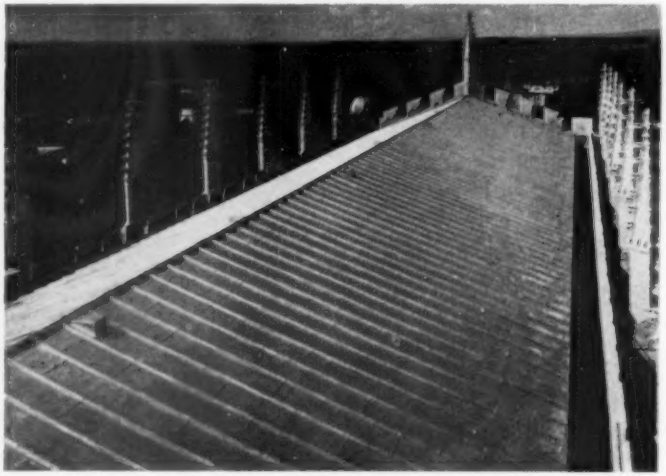
The company said that the continued production of magnesium at the Aluminium Co. of Canada Ltd.'s smelter at Arvida, Quebec, is uneconomic and is being indefinitely suspended. The plant has an annual capacity of 4,000 tons of magnesium.

In future, Magnesium Co. of Canada Ltd. (Magcan) will get magnesium for its sales in world markets partly from the Dow Chemical Co. under the terms of the agreement which provide for the exchange of increasing quantities of both metals as required. Part of Magcan's requirements will also be obtained under an agreement with the Canadian company, Dominion Magnesium Ltd.

SUPER-PURITY ALUMINIUM IN ETON ROOF

THE specification of super-purity aluminium—supplied by the British Aluminium Co. Ltd.—for the weathering of the new roof of Eton College chapel, is representative of the changing attitude of architects and builders towards the light metal. Although the material has now been in regular use for over 60 years, it is only comparatively recently that aluminium has become a conventional building material rather than a new and experimental one.

The picture shows a view across the roof of the 15th Century building. The architects were William Holford and Partners, and the executive architect was Edward Duley. The super-purity aluminium will eventually weather to an even medium-grey colour, in keeping with the original appearance of the chapel.



Books for Your Library

Sheet Metal Shop Practice. Leroy F. Bruce. London: 1959. The Technical Press Ltd., London, S.W.3. 265 pp., 40s. net.

AS an introduction to sheet-metal work this book has much in its favour. Beginning with a chapter which deals somewhat fully with the tools used by the sheet-metal worker, from simple hand tools to bench and machine tools with which every sheet-metal workshop should be equipped, the author goes on to describe the common materials and supplies used in this class of work. Next, the processes of working sheet metal are dealt with systematically, which include cutting, folding, punching, drilling, riveting, grooving, crimping, beading and wiring. There is a useful chapter on soldering which covers the process in detail as well as the preparation of soldering fluxes.

Towards the end of the book the principles of pattern development are dealt with, covering the three principal methods, radial line, parallel line, and triangulation. The chapter on radial line development includes the development of right cones and its frustums, and also square and hexagonal prisms. That on parallel line development covers pipe elbows and tee joints between pipes of equal diameters, and the chapter on triangulation deals with tallboy transformers and ordinary breeches pieces. The section on pattern development does not take the subject sufficiently far to meet the requirements of the average craftsman, but is a useful introduction to the subject for the beginner. Finally, a short chapter on electric welding concludes the work.

On the whole this book is an excellent publication for the young student of sheet-metal work, particularly those still attending prevocational schools.

A. DICKASON.

Fliesspressen von Stahl. Heinz D. Feldmann. Berlin: 1959. Springer-Verlag. 208 pp. DM. 31.50.

TWENTY-FIVE years ago the first reported experiments on the cold extrusion of steel were made in the Neumeyer workshops at Nürnberg. As a result of the developments which followed these first bold experiments, cold extrusion ceased to be confined to the soft metals and a new mass-production technique of remarkable potentialities was born. Evidently this was soon appreciated by the German authorities, for little information about the process leaked out of Germany until after the end of World War II. From this time interest in the cold extrusion of steel has become widespread, but there is still a serious lack of authoritative published information which can guide the manufacturer who is considering an application of this specialized technique in his own production.

For this reason a book on the cold extrusion of steel written by an engineer who has been closely concerned with developments at Neumeyer, and who is an acknowledged world authority on the subject, is a timely and important event. It is to be hoped that British engineers who seek an introduction to the subject will not be too greatly deterred by the fact that it is in the German language. Simple presentation and numerous diagrams provide a considerable reward for a small effort in translation.

For a book of just over 200 pages the treatment of the subject is remarkably comprehensive. After a short descriptive introduction the theoretical background of the subject is discussed in the second chapter, but the objectives in this section, as in the whole book, are essentially practical. Calculations of the work of deformation and of tool loads are based on a relatively simple mathematical approach, using approximate equations. A particularly simple treatment, illustrated by worked examples, makes use of factors for the material's resistance to deformation and the efficiency of deformation which are evaluated experimentally. Nomograms are provided for estimating load requirements for a wide range of materials and conditions of extrusion. Perhaps even more useful are the experimental determinations of working loads and power consumption given in the next section. These cover a fairly wide range of carbon steels and a variety of conditions of extrusion.

There follows a discussion of the characteristics of different types of steel in the context of the cold extrusion process. Attention is given to composition, microstructures, methods of testing and examination of flow-line structures. In a useful appendix, graphs for the work and the deformation loads are given for eight different steels, together with their analyses and microstructures.

Subsequent sections deal with design of components for extrusion with illustrations of a great variety of components successfully extruded and a number of worked examples of the design methods used. Brief comparisons are made with some alternative methods of production. Later chapters deal with tool design, tool materials, presses and special equipment. Those who have practical experience of cold extrusion may be disappointed that Dr. Feldmann has not found space to set out his views on tool design and press design even more critically and in greater detail. Clearly these are of crucial importance in a process involving punch loads often well in excess of 100 tons per sq. in. It may be argued that the space given to such subjects as elementary metallurgy, the design of transducers for load measurements, types of furnace and even protective atmospheres, might well have been sacrificed to increase the penetration and precision of these more vital sections.

The book is well printed and produced by Springer-Verlag and it is surprising to find it lacks an index. It should also be mentioned that practically no references are made to British or American work since 1953 in an otherwise useful literature survey.

However, there is no doubt that this book will be useful to all who work in the field of the cold extrusion of steel and as an introduction to the subject it can be recommended unreservedly.

D. V. WILSON.

Compilation of ASTM Standards Relating to Coated and Uncoated Iron and Steel Sheet and Strip, A-1, A-5. Philadelphia: 1959. American Society for Testing Materials, 1916 Race Street, Philadelphia, Pa., U.S.A. 148 pp. $3.

THESE ASTM standards relating to coated and uncoated iron and steel strip are being issued for the first time. There are 21 standards in the volume including 11 specifications for steel sheet and strip, three specifications for metallic coated steel sheet, two specifications for wrought iron sheet, and one specification for metallic coating materials. In addition there are four methods of test.

Handbook on Non-destructive Testing. London: 1959. British Welding Research Association, 19, Fitzroy Square, London, W.1. B.W.R.A. have informed us that the above publication is now out of print.

APPOINTMENTS and STAFF CHANGES

A.E.I (Rugby) Ltd., formerly the British Thomson-Houston Company Ltd., announce the appointment of Mr. D. Edmundson, B.Sc., M.I.E.E., as general manager, Rugby Works. This will enable Mr. H. E. Cox, who has been general manager since 1957, to devote his time to the duties of deputy director of Manufacture.

Mr. Edmundson, a native of Gateshead-on-Tyne, was educated at Saffron Walden and Rugby College of Technology and Arts and served an engineering apprenticeship with BTH. In 1934, he became a design engineer in A.C. Engineering Department, Rugby, and liaison engineer with Motor Department, Trafford Park, Manchester. In 1940 he was appointed head of the Electrical Laboratory, and in 1946 test engineer, Rugby Works, eventually becoming superintendent, Test Department. In 1957, Mr. Edmundson became assistant manager—Manufacturing, being promoted manager—Manufacturing on January 1, 1959.

* * *

The Minister of Labour, Mr. Edward Heath, announces that he has re-appointed the Rt. Hon. Lord Crook, J.P., and Mr. J. C. Poole, C.B.E., M.C., to be chairman and vice-chairman respectively of the National Dock Labour Board for the period January 1 to December 31 1960.

He has also appointed the four employers' representatives and four workers' representatives nominated by the National Joint Council for the Port Transport Industry to serve as ordinary members on the Board for the same period.

* * *

Mr. B. Rosen has been appointed managing director of **Sandvik Swedish Steels Ltd.,** Halesowen, Birmingham.

He succeeds Mr. Olof Grundberg, who has been managing director since 1947.

The following senior appointments to the Spencer Works, now under construction at Llanwern, near Newport, Mon., are announced by **Richard Thomas and Baldwins Ltd.:**—

Mr. D. Benallick, chief accountant and general office manager; Mr. L. B. Davies, commercial manager; Mr. F. C. Fone, office manager; Mr. W. M. Goatman, public relations officer; Mr. K. Hollingsworth, manager, staff and labour relations department; Mr. D. Knights, traffic manager; Dr. G. G. Mathew, medical officer.

The appointment of Mr. W. O. Campbell Adamson as general manager, Spencer Works, was announced last year.

* * *

The Pressed Steel Co. Ltd., announce that Mr. John L. Lutyens, M.A., A.M.I.Mech.E., has joined its organization as group director of research, and becomes a member of the Motorcar Body Divisional Board.

Mr. Lutyens was educated at Rugby School and Clare College, Cambridge, where he obtained a first class honours degree in mechanical sciences. He served in the Royal Engineers during World War II with the rank of Major.

* * *

Mr. K. W. Sims has been appointed export promotion manager of **C. C. Wakefield and Co. Ltd.,** parent company of the Castrol Oil Group.

Kenneth Sims, who is 39, joined the company in 1951 as an industrial oil sales representative. In 1954 he was transferred to the Overseas Division and posted to Cyprus as resident manager, Middle East. Three years later, he returned to headquarters and was then attached to the Group's American subsidiary, Castrol Oils Inc., as sales manager.

* * *

Mr. Hartford M. King, O.B.E., sales director of **Geo. W. King Ltd.,** Stevenage, Herts, has been appointed assistant managing director.

Top
Left to Right.—

JOHN L. LUTYENS

W. M. GOATMAN

Bottom

HARTFORD M. KING, O.B.E.

* * *

Associated Electrical Industries Ltd., have appointed Sir Arthur Elton, Bart., to be Controller of their Central Information Department. Sir Arthur was formerly in the Public Relations Division of Shell International Petroleum Co., and before that was chairman of the Film Centre and adviser to Shell and other companies.

Mr. S. C. Leslie, who was appointed a year ago as A.E.I.'s consultant on information policy has been acting for the past six months as the head of the Central Information Department during the process of its establishment. He will now resume his consultancy duties in the wider field of both external and internal policy on information.

(*Continued in facing page*)

Appointments and Staff Changes

(Continued from preceding page)

S. W. BARTLAM

Mr. S. W. Bartlam who, for 47 years has been export manager of **W. Canning and Co. Ltd.** retired at the end of 1959. During his long period of service with the company Mr. Bartlam had contact with almost every country in the world.

* * *

Dr. Maurice Cook, who has been chairman of **I.C.I. Metals Division** for the past two years, retired from the company's service at the end of last year. His successor is Mr. Michael Clapham, a joint managing director.

Dr. Cook Ph.D. (Cambridge), D.Sc. (Manchester), joined the research department of Kynoch Ltd. in 1926. He was appointed research manager of the Metals Group of I.C.I. in 1938, and director in charge of research and development, Metals Division, in 1942. He became joint managing director in 1951 and chairman in 1957. Until his retirement he was a director of Yorkshire Imperial Metals Ltd.

Dr. Cook has served on the General Council of the British Standards Institution, the Inter-Service Metallurgical Research Council, the Welding Research Council, the Council of the Electro-depositors' Technical Society and the Ministry of Supply Metallurgy Committee.

A former president of the Institute of Metals, Dr. Cook is also a past-president of the Institution of Metallurgists (of which he is a Founder Fellow). He is chairman of the British Non-Ferrous Research Association, a vice-president of the British Non-Ferrous Metals Federation, a member of the board of the British Nuclear Energy Conference and a member of the general board and executive committee of the National Physical Laboratory.

Mr. G. A. D. Smith has been appointed commercial managing director of the Metals Division.

Mr. Smith, who is 47, joined the secretary's department of the Division in 1936.

After war service, Mr. Smith was appointed personal assistant to the commercial managing director of Metals Division. He is at present vice-chairman of the British Non-Ferrous Metals Federation Rolled Metal Group, chairman of the Locomotive Plate and Rod Group and a member of the Federation Council. He was appointed to the board of I.C.I. Metals Division in 1951 and has since served as sales director and commercial director.

* * *

Dr. J. G. Pearce, C.B.E., has been appointed as a consultant to the Alloys Division of **Union Carbide Ltd.,** and will work in collaboration with Dr. A. M. Sage and his team in their development programmes.

Mr. G. V. Jones, A.I.M. has joined the Development Department of the Alloys Division. He will mainly be concerned with developments associated with the cast iron industry.

* * *

Pearson Panke Ltd. announce that Mr. Leslie Power has recently joined their staff as representative for the Midland area.

The appointment is in line with their general policy to employ qualified engineers as representatives. Mr. Smith has considerable experience of power presses and machine tools and will deal with the full range of Schuler and Schuler-SMG mechanical and hydraulic presses, and sheet metal working machinery, Ungerer roller levellers, Erichsen sheet metal testing machines, E.S. photo-electric guards, etc.

* * *

Mr. W. H. Wentworth Ping has been appointed general sales manager of **Firth-Vickers Stainless Steels Ltd.,** of Sheffield. Mr. Ping was previously sales development manager.

Mr. D. G. Gill-Davies has been appointed export sales manager and Mr. D. W. Smith, assistant export sales manager.

* * *

Mr. S. C. Sidaway has recently joined **Electro Mechan-Heat Ltd.,** of Lower Teddington Road, Kingston-on-Thames, Surrey, as representative in the Midlands and Northern Counties. Mr. Sidaway was previously with The British Federal Welder and Machine Co. Ltd.

Wingard Ltd., Chichester, announce that Mr. L. A. Dumper, A.M.I.W.M., A.M.B.I.M., has been appointed a director.

Mr. Dumper joined the company in 1955 as production controller, being promoted to works manager in 1956 and divisional controller in 1958. The position he now holds is director and divisional controller of the Manufacturing Division.

* * *

Mr. A. W. Graham has taken over the appointment of manager, Northern Area **Electro-Chemical Engineering Co. Ltd.** from Mr. H. Maxwell. His address is Chaddock Industrial Estate, Astley, Nr. Manchester. Tel.: Atherton 1364.

Mr. Maxwell has been appointed sales manager and will operate from the company's head office at Sheerwater, Woking, Surrey.

* * *

Wakefield-Dick Industrial Oils Ltd. have appointed J. W. Davies as their representative for the Sheffield area, in succession to A. S. Watson, who has retired after 35 years' service with the company.

After war service with R.E.M.E., John Davies, who is 35, joined Davy and United Engineering Co. Ltd. in 1947 and became successively, section leader, assistant lubrication engineer and, finally, engineer-in-charge of the lubrication department.

* * *

Mr. Frank W. Townsend, M.B.E., manager of the model shop and test gear department of **The Plessey Company Ltd.,** retired recently after 28 years' service with the company.

Mr. A. G. Clark, chairman of the company presented Mr. Townsend with a motor mower and a cocktail cabinet complete with drinks and glasses.

* * *

Mr. J. L. Steane has joined the staff of **The Bronx Engineering Co. Ltd.,** as sales engineer. He has wide experience of the equipment manufactured for the sheet and plate metalworking industries and will have special responsibilities in areas extending from the north Midlands to the north of England.

* * *

Elcontrol Ltd. announce that Mr. B. A. Worswick, B.Sc. (Hons.), A.Inst.P., has been appointed technical director with a seat on the board.

Mr. Worswick was until recently chief engineer of Fischer and Porter Ltd., and previously chief development engineer of Bailey Meters and Controls Ltd., after having served for some years with I.C.I. Ltd.

Forthcoming Events . . .

March 4

Institute of Metal Finishing (London Branch). Fourth Annual Practical Platers' Night, at the Constitutional Club, 28, Northumberland Avenue, London, W.C.2. 6.30 p.m.

March 9

Institute of Welding (South London Branch). "The Future of Gas Shielded Welding," by A. A. Smith, at 54, Princes Gate. 7.30 p.m.

Institute of Sheet Metal Engineering (Midland Branch). Annual general meeting and film show, at the College of Technology, Gosta Green, Birmingham. 6.45 p.m.

North Wales Metallurgical Society. "The Physical Chemistry of Steelmaking," by J. Pearson (B.I.S.R.A.), in the Lecture Theatre, Flintshire Technical College, Connah's Quay. 7 p.m.

March 14

Institution of Plant Engineers (Merseyside and North Wales Branch). Annual general meeting and film, "Tubular Engineering," at the Exchange Hotel, Liverpool. 7.15 p.m.

Sheffield Metallurgical Association (joint meeting with **Society of Engineers and Metallurgists**). All-day symposium on the hot extrusion of steels.

March 15

Institute of Sheet Metal Engineering (South West Branch). "The Designer versus the Production Engineer," discussion in the department of engineering, University of Bristol. 7 p.m.

March 16

Institute of Welding (North London Branch). "Improved Steels and their Weldability," by J. F. Wilkinson, at 54, Princes Gate, S.W.7. 7.30 p.m.

Institute of Sheet Metal Engineering (North West Branch). Annual general meeting and film show, at the Manchester College of Technology. 7 p.m.

Society of Instrument Technology (Bristol Section). "Hydraulic Servos," by Prof. E. B. Pearson, in the Department of Physics, University of Bristol, The Royal Fort, Bristol, 8. 7.30 p.m.

March 17

Institute of Metals (Birmingham Local Section). Annual general meeting and chairman's address, at the College of Technology, Gosta Green, Birmingham. 6.30 p.m.

Newport and District Metallurgical Society. "Manufacture of Tonnage Oxygen and its Influence on Steelmaking," by J. L. Harrison (British Oxygen Gases Ltd.), at the Whitehead Institute, Cardiff Road, Newport, Mon. 7 p.m.

March 22

Society of Instrument Technology (Cheltenham Section). "Machine Tool Control," by H. A. Prime, at the Belle Vue Hotel, Cheltenham. 7.30 p.m.

March 30

Institute of Sheet Metal Engineering (Wolverhampton Section). Annual general meeting and lecture, "Tool Steels," by C. Hellberg (Uddenholm Ltd.), at the College of Technology, Wulfruna Street, Wolverhampton. 6.45 p.m.

The Institute of Metals. An Educational session on New Aspects of the Electron Theory of Metals, at Hoare Memorial Hall, Church House, Great Smith Street, London, S.W.1. 2.30 p.m.

March 31

The Institute of Metals. Discussion on "Rolling Hard Material to Thin Gauges," at Church House, Great Smith Street, London, S.W.1. 10.0 a.m.

The Institute of Metals. Discussion on "Vacancies, Ageing and Precipitation," at Convocation Hall, Church House, Great Smith Street, S.W.1. 10.0 a.m.

SOLVENTS CAPACITY TO BE INCREASED

I.C.I. is to build a major extension to its trichlorethylene and perchloroethylene plants at Castner-Kellner Works, Runcorn, at a cost of £1,000,000.

Technical service and development work on the uses of these two solvents has been carried out by I.C.I. over many years, and this has led to a growing demand for both products, particularly in the engineering industry for metal-degreasing and also for dry-cleaning.

This extension will increase the combined capacity for these two solvents by 25 per cent, and will enable I.C.I. to satisfy the demands of the home market for several years ahead and permit a further increase in its present considerable export trade.

MANUFACTURE OF SCHULER PRESSES IN THE U.K.

L. SCHULER AG. of Goeppingen, West Germany and B. and S. Massey Ltd., Openshaw, Manchester, England, announce the successful completion of a Licence Agreement under which B. and S. Massey Ltd. will manufacture the well-known Schuler friction screw presses.

The range of these presses to be built is made up of machines for embossing and stamping work, and for hot pressing work, and it further includes presses with wide frames for large components and bending work. The supply of friction screw presses from B. and S. Massey Ltd. will commence early in 1960. Enquiries should continue to be addressed to: Pearson Panke Ltd., 1-3, Hale Grove Gardens, Mill Hill, London, N.W.7.

ABSTRACT AND BOOK TITLE INDEX CARD SERVICE

THE Iron and Steel Institute is starting an Abstract and Book Title Index Card Service which will consist of pre-publication copies of all abstracts (together with titles of new books) due to be published in the *Journal of The Iron and Steel Institute*. Beginning with the abstracts published in the January, 1960 issue of the *Journal*, the service will continue regularly in advance of the publication of the abstracts and book titles in the *Journal* (where they will continue to be printed).

The new service will be in the form of 5 x 3 in. cards (the international library size) sent to subscribers fortnightly, arranged and packed in alphabetical order of authors.

Abstract Cards will each contain:—

(1) Name of author (or authors) at the top of the card, enabling a simple alphabetical name index to be compiled: where more than one author occurs, additional cross-reference cards can easily be made by subscribers and need carry only the name of additional authors with a reference.

(2) A classification number or numbers according to the Universal Decimal Classification system (U.D.C.).

(3) Name and date of the original publication.

(4) Abstract of the article.

Book Title Cards will each contain:—

Titles of new books with U.D.C. numbers and with the names of authors displayed at the top of the card.

Publications for Industry

"Welding Nimonic Heat-Resisting Alloys for Gas-Turbine Assemblies" is the title of a completely new publication which provides the latest technical data and operating instructions for oxy-acetylene, argon-arc, metal-arc and flash-butt welding of the Nimonic alloys for gas-turbine assemblies.

Included are tables showing specified compositions, physical properties, recommended heat-treatments and appropriate welding materials (filler wires, fluxes and electrodes) for Nimonic alloys.

The introductory section of the publication outlines the development of the Nimonic series of heat-resisting alloys from the date of their first production in 1940 to the present time.

Copies of this publication can be obtained free on request from Henry Wiggin and Co. Ltd., Publicity Department, Thames House, Millbank, London, S.W.1.

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In view of the increasing interest, and use of, corrective/protective lenses in safety spectacles in British industry, the Safety Equipment Division of J. and R. Fleming Ltd., 146, Clerkenwell Road, London, E.C.1, have published a booklet entitled "Eyes at Work," which is obtainable from them on request.

In addition to technical information concerning ARMORGLAS toughened corrective/protective lenses, the booklet contains information on their prescription and dispensing through the usual opthalmic channels together with details of fees approved by the Association of Optical Practitioners for the professional services involved. In the booklet a special prescription order form, which is available without charge to industrial concerns or to opthalmic practitioners supplying industry, is reproduced.

Copies of the booklet are available on request from Fleming Safety Equipment at the address above.

* * *

In the glass industry today platinum is accepted as an essential tool in the production of a wide variety of ware, from the humble bottle to the finest optical glass, from the electric-light bulb to the glass-fibre insulating material.

The main article in the January issue of "Platinum Metals Review," published by Johnson, Matthey and Co. Ltd., smelters and refiners of the platinum metals from the Rustenburg Platinum Mines of South Africa, surveys the most important of these applications and outlines some newer developments.

Contributed by Dr. Eric Preston, the well-known consultant to the glass industry, the article emphasizes that the use of platinum equipment in the melting and working of glass has always resulted in an economy in manufacture, due entirely to the production either of a purer glass or of a glass free from defects of various kinds.

Other articles in this issue deal with the palladium plating of printed circuits, the constitution and properties of the iridium-platinum alloys, and the behaviour of platinum-faced titanium and tantalum electrodes for cathodic protection in fresh waters.

The usual compilation of abstracts of current literature on the platinum metals and their alloys is also included.

Copies may be obtained on request from the publishers, Johnson, Matthey and Co., Ltd., 78, Hatton Garden, London, E.C.1.

* * *

The subject of a brochure published by Metalectric Furnaces Ltd., Smethwick, is continuous bright annealing. Furnaces both of the mesh-belt-conveyor and roller-hearth types are manufactured by the company, in addition to complete equipment for the provision of the required furnace atmosphere.

* * *

"Cobalt" is published by the Centre d'Information du Cobalt, Brussels, and in a recent issue an article is given on the corrosion resistance of some stainless steels alloyed with cobalt. Among the conclusions reached is the fact that the favourable influence of cobalt on the intergranular corrosion resistance of the 18 per cent Cr. steels seems to be similar to that of nickel, but is actually more pronounced. The effects of cobalt on ferritic steels are due in part to its γ-field broadening effect (from this point of view its behaviour is comparable to that of nickel) and in part to a specific effect that cannot as yet be clearly defined.

* * *

The excellent resistance to corrosion by the products of combustion of leaded fuels offered by the 80/20 nickel-chromium alloy, manufactured by Henry Wiggin and Co. Ltd., has long been established. This alloy is extensively used either as a protective coating to exhaust valves during manufacture or, frequently to reclaim burnt-out valves.

The technique of applying the protective coating of B.A.C. Brightray nickel-chromium heat-resisting alloy to these valves is fully explained with illustrations in a revised publication ("Brightray Coated Exhaust Valves") by Henry Wiggin and Co. Ltd. It also shows how this material is used to reclaim burnt out valves.

Experience recently gained has been extended with a result that in addition to their continued use for aero engine exhaust valves, Brightray-coated valves are now extensively used in the motor car industry. This publication can be obtained free on request from Henry Wiggin and Co. Ltd., Publicity Department, Thames House, Millbank, London, S.W.1.

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An illustrated brochure, published by Warwick Rim and Sectioning Co. Ltd., Golds Green, West Bromwich, Staffs., describes the advantages of designing with cold-rolled sections and shows the company's facilities for producing them in girth widths up to 17 in., and in thicknesses from 0.005 in. to 0.187 in.

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A new publication issued by Coventry Radiator and Presswork Co. Ltd., Coventry, provides an outline of the history, organization and technical resources of the company. Beginning in the latter part of the 19th Century the company played a major part in the development of the automotive industry during its formative years, and to meet the demand for its products the company built a new factory at Canley in 1930. This factory has since expanded into the modern plant illustrated in this book. The activities of the company have for many years extended into other fields of industry, in addition to the motor trade, and the recent completion of its new and modern press shop has greatly increased capacity for the production of a wide range of products, which includes radiators, clutch housing, sumps, fans, space heaters, condensers, oil coolers, heat exchangers, etc.

J. H. FENNER IN SOUTH AFRICA

J. H. FENNER and CO. LTD., have announced the formation in Johannesburg of J. H. Fenner and Co. Africa (Pty.) Ltd., which plans, in conjunction with Reunert and Lenz Ltd., the manufacture of a range of mechanical power transmission goods in the Union.

NEW COMPANIES

"Ltd." is understood, also "Private Co." Figures — Capital, Names — Directors, all unless otherwise indicated.

ROGERSTONE PRECISION, Wern Avenue, Rogerstone, Newport, Mon. December 9. £20,000. *To carry on bus. of engineers, etc. Gerald N. Hunter, Cecil J. Manning, Lloyd C. Burton.*

R. W. OWEN, 231, Church Road, Thundersley, Essex. December 10. £1,000. *To carry on bus. of tool, pattern and machinery designers, etc. Rupert W. Owen, Yvonne A. Owen.*

A. P. L. THOMAS, Marston Hall, Marston Green, Birmingham. December 10. £1,000. *To carry on bus. of machine tool manufacturers, etc. Archibald P. Thomas, Alan P. L. Thomas.*

QUALCOM, 68, Manor Road North, Hinchley Wood, Esher, Surrey. December 10. £100. *To carry on bus. of manufacturers and merchants of plastic metal moulded electronic and general engineering components, etc. Alexander Briggs, Mrs. Rita Briggs.*

MECHANICAL JOINTS (BIRMINGHAM), 141-147, Lionel Street, Birmingham. December 10. £100. *To carry on bus. of iron-founders, mechanical engineers, machinery manufacturers, etc. Francis W. N. Duffield, Patrick J. H. Riley, Alfred T. Bowater.*

ALCAN (U.K.). December 14. £500,000. *To carry on bus. of principal, or as agent, commission merchant or consignee, the business of purchasing, importing, exporting, selling or supplying aluminium or any other metal, etc. Directors not named.*

R.P.C. WELDING CO. (CAERPHILLY), Bartlett Street Works, Caerphilly, Glam. December 10. £3,000. *Robert W. C. Lewis, Archibald Darling, Kenneth H. George, Royston D. Roberts, Leonard C. Powell, Walter H. C. Cooper, Patrick Murphy.*

INERTIA SWITCH, Craven House, 121, Kingway, W.C.2. December 14. £5,000. *To carry on bus. of electric, mechanical and electronic equipment specialists, etc. Henry Kremer, Walter W. H. Clarke.*

T. AND T. WELDING, Dove Hill Works, Boxley Road, Maidstone, Kent. December 16. £500. *Walter S. Townsend, Rodney D. Townsend.*

H. A. WRIGHT (STEEL EQUIPMENT), 144-6, Gt. North Road, Hatfield, Herts. December 17. £1,000. *To carry on bus. of manufacturers of and dealers in steel cabinets, furniture, etc. Hubert A. Wright.*

KINGSWINCO, 3, Dawley Brook, Kingswinford. December 18. £2,000. *To carry on bus. of makers and refiners of and workers in metals of all kinds, etc. Douglas K. Bacon, Alexander Mallen.*

NEWBOULD AND DUNN, 22, Grammar School Road, Latchford, Warrington. December 18. £1,000. *To carry on bus. of machinery and metal merchants, etc. Arthur Newbould, Peter Dunn.*

J. J. SPENCE (LEEDS), Poplar Cafe Yard, Barwick Road, Seacroft, Leeds, 14. December 18. £500. *To carry on bus. of engineers, toolmakers, etc. John J. Spence, Mrs. Marjorie Spence.*

HADFIELD AND PARTNERS, Railway Terrace, Redcar. December 18. £5,000. *To carry on bus. of steel stockholders, metal merchants, etc. Horace E. Hadfield, Cyril Raw, Dorothy S. Hadfield, Marjorie Raw.*

FIN-FAN. December 21. £1,000 *To carry on bus. of manufacturers of and dealers in copper, steel and other gilled tubes, appliances and equipment, etc. Wallace J. Harwood, London Road, Pulborough, Sussex, Mrs. Dorothy M. Harwood.*

THOMAS OAKLEY (STEEL), 2, Beechwood Road, Luton. December 21. £10,000. *To carry on bus. of steel stockholders, metal merchants, etc. Thomas Oakley.*

CREW STEEL, London Fields, Newey Street, Dudley. December 21. £10,000. *Arthur Crew, Christopher F. Eccles, Christine Hayward.*

JAMES BOOTH ALUMINIUM, Argyle Street Works, Nechells, Birmingham. December 21. £100. *To acquire the whole or part of the business of James Booth and Co. Ltd., which consists of the manufacture of wrought aluminium alloys and other aluminium products, etc. Directors not named.*

WESTERN STEEL AND NON-FERROUS STOCKHOLDERS, Sloper Road, Cardiff. December 21. £1,000. *Charles P. Heald, Samuel C. Kellow, Arnold G. Kyrke, Charles L. Field.*

ELWELL SECTIONS, Elwell Street, West Bromwich. December 22. £2,000. *To carry on bus. of metal rollers, pressers, etc. Betty Hughes, Ivan T. Field.*

F. T. DAVIS (KINGS LANGLEY), Primrose Hill, Kings Langley. December 23. £1,000. *To carry on bus. of factors and dealers in, importers and exporters of, repairers and refiners of general sheet and art metal work, etc. Fdk. T. Davis, Arthur F. Walker, Gladys J. H. David, Eric D. Jordan.*

J. W. ENTWISTLE, Brindleheath Works, Cobden Street, Salford, 6. December 23. *To take over bus. of sheet metal workers carried on at Salford by J. R. Walton. John R. Walton, Mrs. H. Walton.*

ALUMINIUM R.W. SUPPLIES, Channel Mills, East Dock, Cardiff. December 23. £500. *To carry on bus. of agents, factors, importers and exporters and repairers of all ferrous and non-ferrous metals, aluminium rainwater goods, etc. Graham D. Rouse, Mrs. B. M. Rouse.*

J. W. HARDWICK AND SONS, Cox Lane, West Ewell, Surrey. December 24. £50,000. *To carry on bus. of scrap metal and general merchants, etc. John W. V. Hardwick, George E. Hardwick, Richard J. Bolton.*

ALLISTER WELDING, 253a, Cranbrook Road, Gants Hill, Ilford, Essex. December 29. £1,000. *Douglas McAllister, Mrs. Florence McAllister.*

JAS. MILNE COOPER, Kobar Works, Ambler Street, Bradford. December 31. £7,000. *To acquire the fixed assets and stock forming part of the undertaking of Jas. Milne Cooper and Co. Ltd. (Incorporated in 1913) and to carry on bus. of manufacturers of and dealers in patent copper jointing rings, piston rings, etc. Fred Carlisle, Lucy Carlisle.*

JAMES KNOWLES (METALS). January 1. £8,000. *To take over the bus. of metal manufacturers and merchants carried on as "James Knowles," at 44, Cambrian Street, Manchester. James R. Dooley, Tom K. Dooley, Constance Dooley, John K. Dooley.*

SHEETS STRIP AND BARS (STEEL), Castle Street Works, Castle Street, Tipton. January 4. £100. *George D. Lees, John N. C. Pugh.*

From the Register compiled by Jordan & Sons Ltd., 16, Chancery Lane, London, W.C.2.

BIRMINGHAM "STEAM UP" AGAIN

ANOTHER "steam weekend" will be held on March 26 and 27 next at the City of Birmingham "Science and Industry" Museum at Newhall Street, Birmingham, 3. Engines built as long ago as 1892 will be in operation under steam in addition to other prime movers such as gas and hot-air engines, etc. A film will also be shown of the dismantling of the Ocker Hill engine (1777) and it is hoped to arrange the showing of other films dealing with prime movers. This museum is unique in so far as many of the exhibits can be operated with live steam.

New Plant and Equipment

Die Shear Lines

DESIGNED and developed by The McKay Machine Company, Youngstown, Ohio, U.S.A., McKaymatic die shear lines are now being built in this country by Vickers-Armstrongs (Engineers) Ltd., at Newcastle. The Rockwell Machine Tool Co. Ltd., Welsh Harp, London, N.W.2, are the sole selling agents in the United Kingdom for this British-made equipment.

McKaymatic die shear lines have been specially developed to cut blanks of any length required, upwards of 9 in., from coiled material. They uncoil, level and cut to length in a continuous operation, no slowing or stopping of the line being necessary when changing the sheet length. An uninterrupted flow of material is made possible by the elimination of any build up of sheet against the shear, owing to the cutting being carried out with the die set in motion at exactly the same speed as the material. On conventional decoilers and roll feeds the material feed is intermittent but in this case it runs continuously at a constant pre-selected linear speed. Lines are built to handle material of widths up to 72 in. and most thicknesses, the capacity of the line illustrated being 48 in. by 10 gauge.

The ability to produce blanks of the exact length required is of great benefit as :—

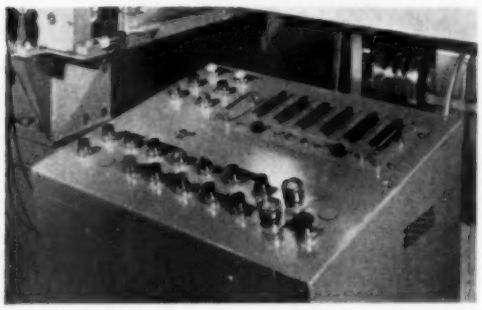
(*a*) Coiled material is cheaper than sheet ;
(*b*) Special sizes do not involve extra expense ;
(*c*) Waste is reduced to the minimum.

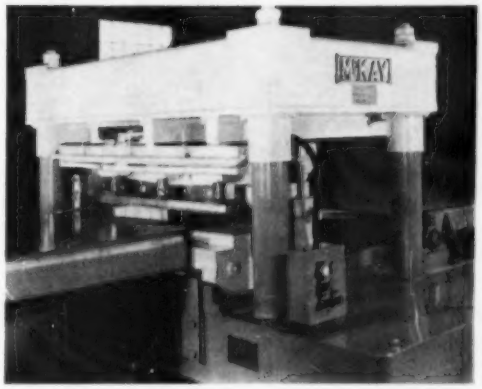
Sheets 4 ft. long can be cut at the maximum line speed of 200 ft. per min., shorter lengths requiring proportionately slower speeds. The minimum line speed is 30 ft. per min. which makes possible the production of sheets only 9 in. long.

Electronic measurement and control keeps the sheet lengths within very close tolerances and makes possible volume output of sheets of different lengths as the sheet length is changed instantly without stopping or slowing the line.

As there is no pit or hump table the lines are considerably shorter than comparable equipment. This is an important feature as floor space is at a premium in most factories.

Any type of coil holder can be applied and cone-type holders with capacities up to 25 tons are available. Mechanical coil loading equipment can be added if required. The illustrated line has a 5-tons capacity McKay expanding mandrel pay-off reel with drag brake and threading drive. Also in the line illustrated is a 17-roll triple backed-up leveller but design and dimensions of the roller leveller vary according to the customers' requirements. Slitting rollers can also be incorporated for trimming the edges of the strip. The material





has a very high degree of flatness on leaving the leveller and, as there is no humping or looping to "set" the metal, secondary levelling is eliminated.

The press is also built to the customer's requirements, the one shown being a 35-ton under-drive four-column two-point suspension press with a.c. motor drive and pneumatic clutch and brake. Standard controls include inching and non-repeat. Lubrication is by a continuous recirculating system.

During a cutting cycle the travelling die accelerates to the line speed, cuts and returns on anti-friction bearings over hardened steel guide rails. The synchronization of the die with the moving material precludes any strip damage normally associated with mechanical length gauging.

Standard equipment includes a pneumatic hold down bar and counterbalances. If notching and/or piercing is to be done near the shear cut the necessary tools can be installed with the standard cut-off blades.

A surface measurement system which includes a pulse generator on the exit punch rolls is transmitted from a common power take-off through a cam motion to the travelling die motion mechanism to ensure identical speeds of material and die. When the die has accelerated to the material speed and reached the required position for cutting the selected length a signal from the counter unit triggers the cutting action. Simultaneously this signal is used as the datum line for measurement of the succeeding sheet. The traverse of the shear die is only 18 in. and of that distance approximately 2½ in. is required for acceleration to the constant line speed. Allowing another 3 in. to 4 in. for deceleration there is a space of about 12 in. where the die is travelling at the same speed as the sheet and during this period the signal for cutting occurs. The travelling die is kept as light as possible.

The operator determines the length of cut sheet and quantity by push buttons on the console. Automatic

Fig. 1 (*left*).— *Control console of die shear line*

Fig. 2 (*above*).—*Travelling die shear*

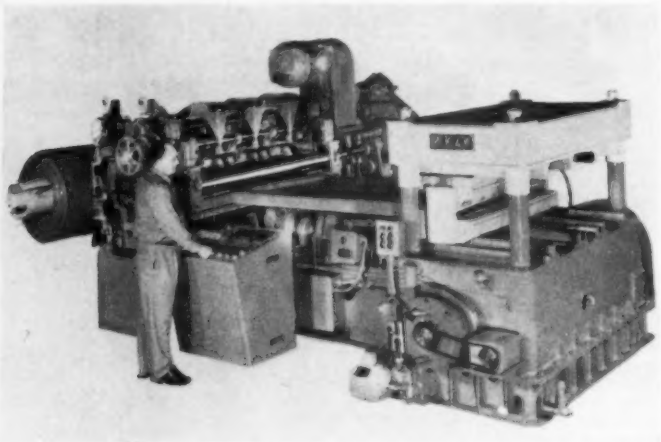


Fig. 3 (left).—Complete McKaymatic die shear line

Fig. 4 (below).—Hydraulic press fitted with roll feed

programming using standard data processing cards, punched tape, or a series of manually preset length and quantity selectors is optional equipment.

For simplicity of maintenance, a.c. drive motors and controls are used in conjunction with a mechanical speed variation. No speed matching of line components is necessary as regulating loops and variable speed drives are not used.

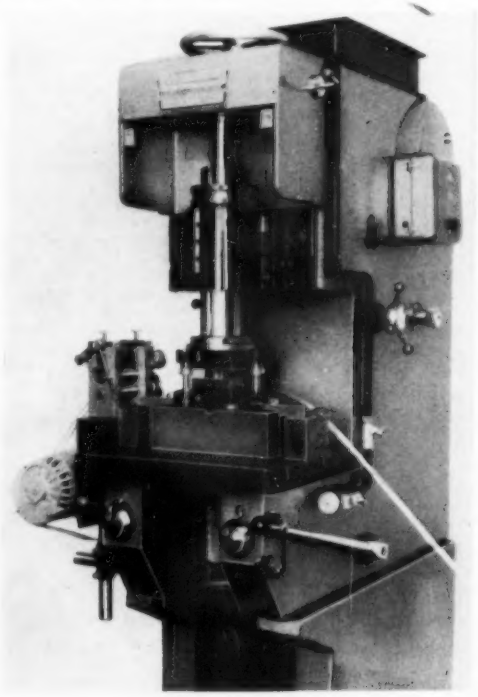
Hydraulic Press and Strip Feed (Fig. 4)

THE Norton Tool Company Ltd. are manufacturing a 7½-ton hydraulic press of outstanding performance and versatility, and the makers claim the following processes for it with very little pre-setting technique; blanking, drawing, forming, forging and hot pressing, assembling and riveting, powder compacting and tool setting. The press is available from Frank Lewis and Co. (London) Ltd., 65, St. Paul's Churchyard, London, E.C.4, who are the sole world concessionaires.

The press itself stands 52 in. high, has a depth of 40½ in. and a maximum width of 20 in. Constructed on the unit principle, to minimize the number of working parts, the entire hydraulics comprises only a pump, two control units for the approach and pressing speeds and a ram assembly. This arrangement in its simplicity gives a very trouble-free performance. An infinitely-variable stroke is a particularly interesting feature of this press and is adjustable from 0.010 to 6 in. A comfortable working area configuration is also given by a throat depth of 8¾ in. and a maximum daylight over bedplate of 16 in. A standard ram of 3½ in. diameter, threaded internally with a 2 in. Whitworth, is fully guided and non-rotating and may be adjusted to take up any resulting wear. A steel platen is supplied as an alternative and is located by two 1½-in. diameter pillars, running in bearings in the ram guides and interchangeable with the standard ram guides. The ram itself has dead stops, top and bottom, the bottom stops controlling the ram to within limits of 0.0005 in. A 2-ton power return, which can be used for either lineal or pressure-sensitive return, enables components to be staked in plastic moulds without damage to the moulding.

A star wheel situated on the left side of the press selects characteristic requirements of the setter in conjunction with a chart supplied with the machine. The star wheel on the right side of the machine governs the high-pressure circuit. Fast approach pressures are controlled by the dial on the right of the star wheel. The right-hand lever controls the press manually and is proportionate in action; a lever on the left-hand side operates the semi-automatic cycling, requiring only very light pressure to operate. Possible settings include, semi-automatic cycling, fully automatic cycling with either variable or vibratory strokes, which ensure stronger and better quality riveting, and manual operation.

The maximum dwell at the top of the stroke is five seconds with a proportionate drop at high speeds and the vibratory strokes may also be set with respect to



both speed and stroke length. Six fast approach speeds and six pressing speeds are available, both of which are adjustable for power, the range of adjustment being, in the case of approach speeds, from a few pounds to 75 per cent of the fully rated tonnage and for the pressing speeds, from ¾ to 7½ tons. The 36 possible ram speeds and an infinitely variable number of strokes per min., up to 600 at a ⅛-in. stroke (more at shorter strokes), make this press extremely versatile.

Any desired set of conditions, from the large number possible, make this a most efficient machine for any number of complicated production requirements. The high ram speeds, combined with full power over the stroke range, enable shear to be provided with either punch or die, and the ram pressure can be set so that the relief valve will operate should two components be present in the die, virtually eliminating tool jamming.

Roll Feed

A double-roll tandem strip feed unit has been designed for use principally with this hydraulic press, and the designers' aim has been to provide a unit to match the speed and versatility of the press. Consequently the feeder is designed to cope with the full range of automatic stroking speeds of the press from 40 to 800 s.p.m.—to be suitable for any length of progression, and to be adjustable readily for any normal weight and gauge of material.

To achieve these characteristics the designers have followed somewhat unconventional lines, recognizing that with most conventional methods of feeding where the progression is set in the feeder, the actual progression obtained in operation may vary considerably with the linear speed and weight of the strip material and with the stroking speed of the press, particularly when the latter reaches the unusually high level of 800 s.p.m. The feeder, therefore, pre-supposes the progression or indexing being built accurately into the press tool by means, for example, of trigger stop or side-crop and provides conditions in which such accuracy can be used to full advantage.

These conditions are instantaneous pick-up, and sensitive control of forward torque, so that the latter is high for progressing the strip, but is low at the moment when the strip is checked and held by stop or side crop in the tool. They are achieved by a simple belt feed from a 1/3-h.p. synchronous motor to the bottom of a pair of hardened-steel rollers by a drive and slip belt specially developed for this type of application, with provision in the drive arrangement for adjusting first, the overall torque, second, the amount of torque transmitted when the strip is at rest, and third, the relation between the latter and the progression torque. Thus, the torque transmitted when the strip movement is checked by the tool can be set so light as to ensure no tearing of low-tensile thin-gauge material against stops, and to allow ready alignment of pilots, while still maintaining adequate progression torque for instantaneous pick-up on release of strip. Inasmuch as the strip is always under control high speeds can be maintained on thin-gauge material without strip flutter. The top roller is also adjustably spring-loaded and a two-diameter reversible pulley is fitted to the motor to give a choice of two roller speeds. The whole unit is mounted on the side of the press and is adjustable both vertically and horizontally. It can be used for either feeding in or feeding out, or two units can be fitted in tandem as a double-roll feed.

The roll-feed unit is suited for feeding not only coiled strip but also guillotined short lengths, since when it is set as a feed-out unit, each length is fully run through and completely clears the tool, leaving the latter instantly ready to accept the next length. In addition operation and progression is unaffected by even serious defects in the form of burrs and kinks.

The units are easily and quickly mounted, set, and dismounted on the Norton press. Consequently setting times even for relatively short runs are economical and operation of the press may readily be changed from high production to general-purpose work and *vice versa*.

At a recent demonstration the press fitted with the feed was shown producing a nickel-silver contact blade, the material being 1-in. wide coil, 28 s.w.g. The tool had two-stages with trigger stop and was piloted on the second stage; progression was $\frac{7}{16}$ in. The feed unit was used on the exit side of the press and the speed achieved was 850 s.p.m. Previous production figures for this component on a crank press with conventional feed was 140 s.p.m. The press and the feed unit fitted with the tool described are shown in Fig. 4.

Oil Mist Spray Equipment

WAKEFIELD-DICK Industrial Oils Ltd., Castrol House, Marylebone Road, London, N.W.1, have introduced an oil-mist unit (Model M.3892) for the application of cutting oils. This unit enables soluble or neat coolants to be fed to the work-face in circumstances where surface speed normally makes dry machining necessary. It functions by delivering a fine mist of coolant in a stream of compressed air.

The unit operates at 10 to 20 lb. per sq. in. and consists of three major components; a porous bronze filter element, a pressure-reducing valve complete with gauge, to indicate the reduced air pressure, and an Ayrlyne lubricator with flow adjustment.

The lubricator embodies a ½- or 1-pint transparent oil reservoir with needle regulating valve controlling the oil flow. The ratio of oil to air can be adjusted by a regulating screw at the top of the lubricator.

The unit is suitable for use with neat cutting oils of a viscosity not exceeding 300 Redwood seconds at 70° F. or with soluble-oil emulsions.

A general view of this equipment is shown in Fig. 5.

Fig. 5.—Oil mist spray equipment

Fig. 6.—Self-contained single-probe thickness gauge

Single-Probe Thickness Gauge

A SINGLE-PROBE miniature layer-thickness meter of rugged construction suitable for measurements on curved surfaces is now available from The O. Hommel Company, Carnegie, Pennsylvania, U.S.A.

The instrument (Fig. 6) is a completely self-contained magnetic gauge and is suitable for use on any magnetic material between the extremes of electrical sheet steel and cast iron. It may be used on any non-magnetic coating material such as paint, enamel, lacquer, plastic or non-ferrous metals, as well as porcelain enamel.

The meter, which measures the thickness of a layer of paint or other protective coating directly without damaging the coating, is available in three measurement ranges : 0 to 0.005 in., 0 to 0.01 in. and 0 to 0.03 in. Readings may be taken in areas where the scale cannot be seen. This is accomplished by a pointer clamp, which traps the pointer in the deflected position and the coating thickness can then be read when the instrument is removed. In taking ordinary readings where the scale is visible, it is necessary only to place the meter on the coating with the pointer clamp depressed and to read direct from the scale.

Bright Copper Plating Process

A NEW bright copper cyanide process with the trade name of Copper-Lume, is announced by the Hanson-Van Winkle-Munning Company, Church Street, Matawan, New Jersey, U.S.A.

Copper-Lume is said to offer the following characteristics : smooth, bright deposits over an extremely wide temperature and current-density range ; good metal distribution ; solution simple to operate and control ; deposits can be buffed with ease, if required.

Copper-Lume bath constituents can include either potassium salts, a mixture of potassium and sodium salts, or sodium cyanide only and the deposits do not require activation before subsequent nickel plating.

In many respects, notably in its ease of operation, the Copper-Lume process is similar to the company's Nickel-Lume process.

Spray Gun for Vitreous Enamel

THE use of vitreous enamel today is steadily increasing and any improvement in technique which leads to a reduction in production costs is of major importance to the industry.

Because of this, and in conjunction with Ferro Enamels Ltd., Alfred Bullows and Sons Ltd., Long Street, Walsall, have produced equipment for applying vitreous enamels at very low air pressures.

This technique of low-pressure enamel application offers several major advantages to the enameller. First, there is a definite economy in enamel used. Second, with a low pressure nozzle it is a simple matter to obtain a very fine coat, which, when fired, is far less brittle than a thick enamel coat would be. Third, the low-pressure technique requires far less skill than normal production methods. Finally, when spraying hollow objects, such as bread bins, spin dryer bowls, etc., "bounce" is a serious problem at normal pressures. Using the low-pressure technique the job is easy.

Suitable nozzles have been developed for this purpose on the L1900 Bullows-Binks Model 19 (Fig. 7*b*) and the L200 Model 2 spray guns (Fig. 7*a*). When using the L1900, best results are obtained with fluid pressures varying between 5 and 12 lb. per sq. in. and with an air pressure of 25 lb. per sq. in. using a 63B x 66PH nozzle. With the L200 a fluid pressure of 5 lb. per sq. in. and an air pressure varying from 25 to 50 lb. per sq. in. can be used. The nozzle was A39 x A5P. The material used for all tests was a standard cover-coat enamel having a specific gravity of 1.34 and a fineness of 3½/200/50.

A parallel development resulting from these tests was that, while mottling in the vitreous-enamel trade has generally been considered a slow process, a great increase in speed is possible with the L200 spray gun. A fluid pressure of 5 lb. per sq. in. and air pressure of 8 lb. per sq. in. is used with the A39 x A8P nozzle.

(*a*) (*b*)

Fig. 7 (left).—Spray guns for vitreous enamel

(*a*) *L200 model 2*

(*b*) *L1900 model 19*

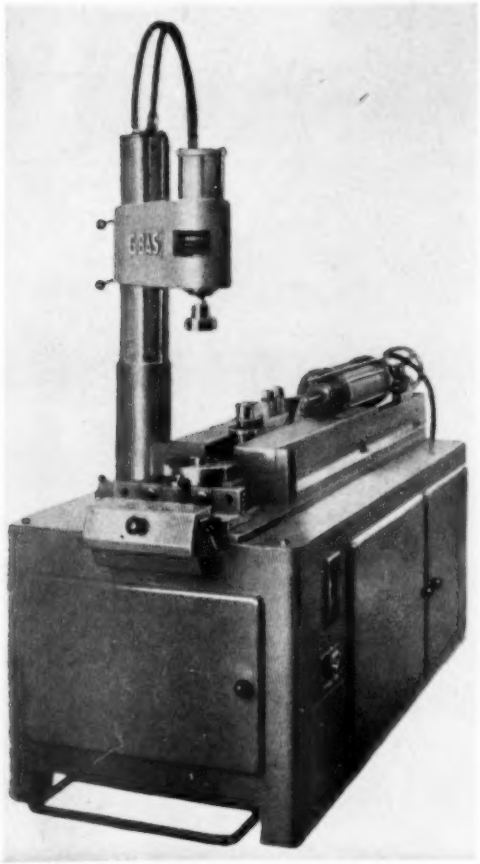


Fig. 8 (above).—Drawn shell trimming machine

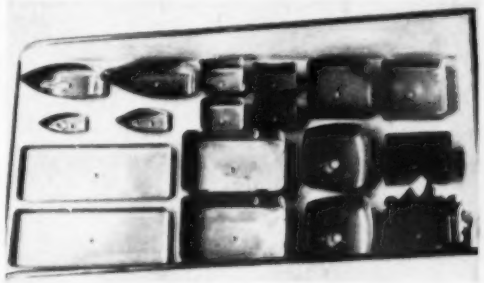


Fig. 9 (top, right).—Typical drawn components trimmed on machine shown in Fig. 8

Trimming Machine for Drawn Shells

THE pneumatically operated, semi-automatic GIBAS drawn shell trimming machine (type TAS) (Fig. 8) has a wide application in all phases of cylindrical, rectangular and polygonal component edge trimming and is designed to overcome the many difficulties presented by components having small corner radii, complex profiles, and large length to width ratios.

The shell is located upon a suitably shaped workholder which is mounted on the vertical main spindle. The shell is then pressed down upon the workholder by a pressure pad operated by a pneumatic cylinder directly above, and in alignment with, the main spindle.

The cutter and guide roll, which are integral, are mounted in a detachable holder fixed to a horizontal slide operated by a pneumatic cylinder; in the operating cycle the cutter engages the workpiece, piercing the metal, and is subsequently held against the workpiece, as it rotates, by pneumatic pressure, until one revolution of the component has been completed, the resulting scrap being parted off and the cutter returned to its initial position.

A special feature of this machine is the provision of an angular setting over the slide guiding the cutter holder to obtain the maximum cutting efficiency on long rectangular or sharp cornered work, together with a selection of variously sized cutters which also play a large part in cutting efficiency on polygonal components. The cycle can be interrupted at any time by an emergency switch and the component is ejected pneumatically on completion of the trimming cycle.

A range of components, excluding the cylindrical types, are shown in Fig. 9. Machines are available in six sizes to cater for a wide range of drawn shells and radial movement of the pressure pad holder, directly above the workholder, can be effected in certain models to permit the placing and removal of deep-drawn components. The machine is available from Broadway Equipment Ltd., Parway House, 194-196, Finchley Road, London, W.3.

Portable Arc-Welding Transformer

THE FARARC 240, the latest version of the Fararc toroidal welding transformer, incorporates a new system of insulation that allows the set to be used for more continuous use on heavier gauge rod without overheating. This is achieved by a new impregnation and baking process whereby the two primary and the secondary windings are independently impregnated and baked. The unit weighs 95 lb., and is contained in a cubic steel and aluminium case with a 14-in. side, the case being finished in a stoved grey hammer finish. The open-circuit voltage is 50 volts and the current range is from 60 to 300 amp. with a continuous rating of 200 amp. The standard windings are for 200/250 and 400/440 volts, but special windings for 110 volts, 500/550 volts and other voltages are available. The efficiency of the transformer is very high, giving a power factor of 0.82; the magnetizing current is under 1 amp. No correction condensers are needed, and the set is approved by various electricity authorities for connexion to rural mains.

The windings are double-glass insulated, wrapped where necessary with glass-woven cloth, the whole being triple impregnated with pure silicone varnish and baked. This insulation will withstand temperatures up to 180° C. without damage. Cooling is by a fan giving 600 cu. ft. per min. over the windings, but as an additional precaution there is a thermostatic switch which, in the event of overheating, cuts off the welding current but leaves the fan working, allowing the set to cool down rapidly.

Further details can be obtained from Portable Welders Ltd., Castle Mills, Buckingham.

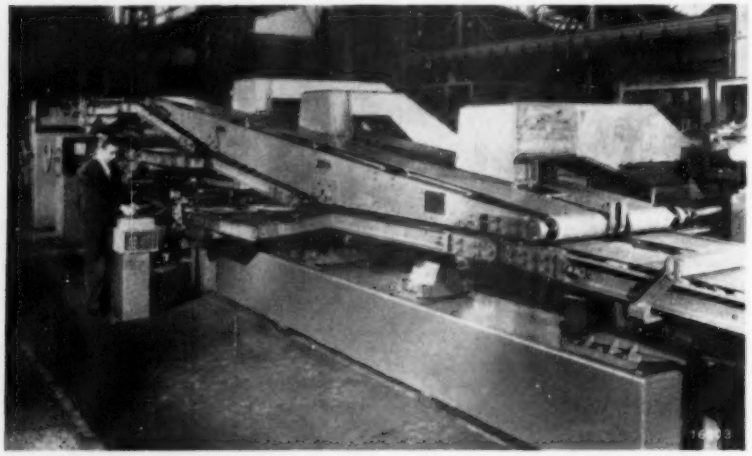


Fig. 10 (left).—Stacking and sorting sheets on high-speed automatic plant

Fig. 11 (below).—Tungsten-steel general-purpose saw

Fully-Automatic Sheet Sorting and Stacking Plant

THE capacities of rolling mills and tinning plants for thin flat products are nowadays generally so large that the conventional finishing line equipment is no longer able to cope with either the amount or the variety of the output. Schloemann Aktiengesellschaft, Dusseldorf, have therefore developed a high-speed fully-automatic plant for sorting and stacking sheets (Fig. 10).

Upon entering the plant the gauge strip is first cut into sheets which are transferred by conveyor belt to the sorting belt. Faulty sheets are thrown off at either of two sorting stations, depending on the type of defect; perfect sheets proceed to the end of the sorting belt. The plant is designed to operate dependably, even at maximum speed, without damaging the surface of the material handled.

A fully-automatic sorting and stacking plant of this kind for dealing with electrolytic tinned sheet in lengths of 14 in. to 59 in. was recently supplied to a foreign mill. This plant operates at a maximum speed of 1,300 ft. per min.

General-purpose Saw for Wood and Metal

THE "Eclipse" No. 66 general-purpose saw (James Neill and Co. Ltd. Sheffield, 11) (Fig. 11) (Regd. Design Nos. 890,827 and 891,263) has a 16in. long tungsten-steel blade which is specially tapered to facilitate sawing in confined spaces; moreover, the blade can be quickly positioned and locked at any one of nine different angles relative to the handle—a feature which makes the saw ideal for cutting materials in awkward positions. The blade clamping screw and wing nut cannot be separated and, therefore, cannot be misplaced or lost.

Tests have shown that this saw will cut easily such materials as hard and soft wood, wood in which nails or bolts are embedded, hard rubber, plastics, fibreboard, and small tubes and bars made from mild steel, copper, brass, aluminium, lead and the like. The blade is extremely hard wearing, but when it does have to be replaced a new blade can be fitted in a few seconds.

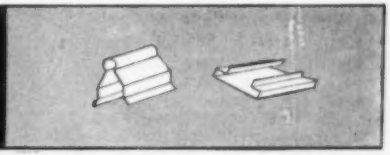
High-speed Hacksaw Blades

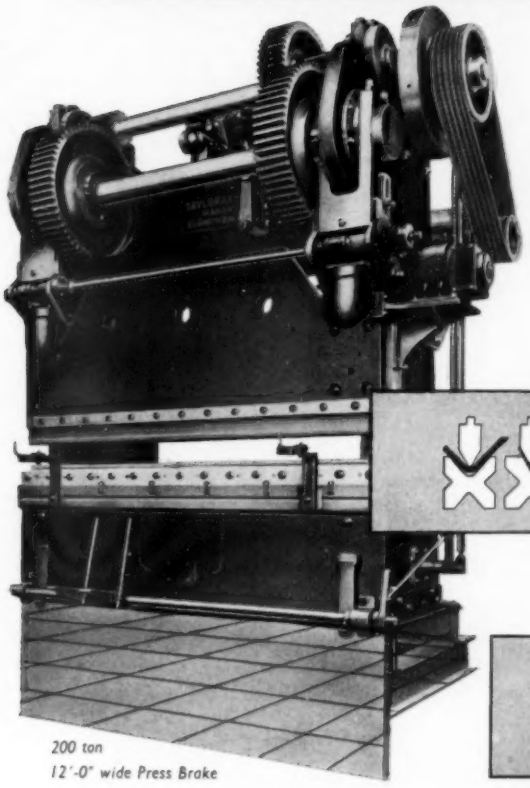
"STEADFAST" high-speed flexible hacksaw blades (Fig. 12) are a new product from J. Stead and Co. Ltd., Manor Works, Cricket Inn Road, Sheffield, 3. The blades which are available in lengths of 10 and 12 in., ½ in. width and 0.025 in. thickness with tooth pitches of 18, 24, or 32 or 14, 18, 24, or 32 respectively are hardened on the teeth only and are claimed to give a cutting performance equal to any normal high-speed hacksaw blade. By virtue of the fact that it is only hardened on the teeth a flexibility is introduced into the blade, thereby helping to eliminate the breakage of blades by unskilled labour.

(*Continued in page* 238)

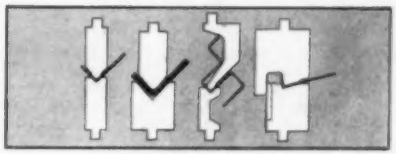
Fig. 12 (right).—Flexible hacksaw blades

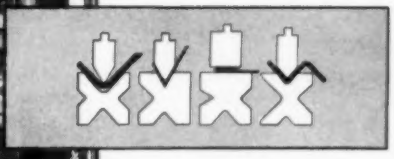
PRESS BRAKES

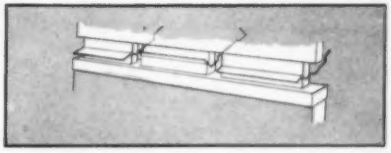


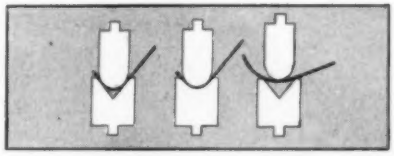


200 ton
12'-0" wide Press Brake









WE ALSO MAKE

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Double sided Presses
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PDPMBA MEMBER

TAYLOR & CHALLEN LTD *BIRMINGHAM 19*

Press Brakes

F. J. EDWARDS LTD. have designed and registered a new series of press brakes, to be marketed under the name of "Besco-Truebend" (Fig. 13). The smallest capacity available in a range of nine sizes is 72 in. by 16 s.w.g. by 20 tons up to a maximum capacity of 120 in. by ¼ in. by 80 tons pressure. The bending capacities are taken over the full tool width and the thickness is naturally increased on shorter plates taken between the side frames which are arranged to receive plates straight through. The very comprehensive range gives the machines exceptionally wide application, not only in the form of the material handled, but to some extent, the type of work handled; the 20-ton brake is most suitable in size and cost for the smaller works with lighter weight and low to high production.

These press brakes are built from heavy rolled steel plates, welded and bolted together to give rigid strength and eliminate deflection. Deep gaps from 6 to 10 in. in the side frames permit the forming of plates longer than the bed in more than one operation. The bed is wide and machined full length; dovetailed slots front and rear will accommodate die setting plates and gauges. Tool height setting is by ram adjustment. In the case of the 20- and 40-ton machines, this adjustment is by hand-operated worm and worm-wheel gear reduction. The remaining five larger machines have the ram adjustment by motor through worm and worm wheel. A setting scale and indicator is provided on all machines.

The machines are arranged for vee-rope motor drive through heavy spur gearing, enclosed in a box running in oil. The balanced flywheel, which is machined all over, incorporates a disc-type clutch operated by a full-length treadle through a series of levers, giving light but positive control to the machine. The brake is connected to the treadle mechanism, allowing the operator to "inch" the ram and maintain complete control during the bending operation.

A band brake is fitted to each of the 20- and 40-ton machines, while the 60- and 80-ton models have shoe brakes. Control of the main drive motor and auxiliary ram-adjusting motor, when fitted, is by flush-mounted, push-button stations on a correctly located contactor box. A single-shot lubrication system is fitted and steel guards cover the gears, drive and crankshaft.

Illustrated leaflets with full specification, are available from the manufacturers F. J. Edwards Ltd., 359-361, Euston Road, London, N.W.1.

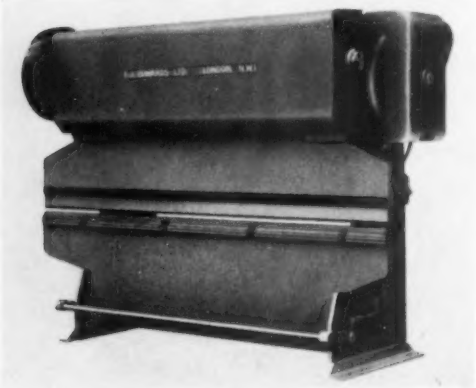

Fig. 13 (above).—Press brake

Press-Shop Automation

R. K. MALLEY AND CO. LTD., Hainge Road, Tividale, Tipton, Staffordshire, who since 1954 have specialized in special-purpose machines, and tool-making, have recently been incorporated as a Limited Company and intend to continue the manufacture of special-purpose machines, press tools, gravity dies, jigs and fixtures as usual, but to specialize in press shop automation. They are offering a complete range of press shop equipment, including power drawn combined coil cradles and strip straighteners, cabinet straighteners, light weight coil holders, roll feeds, pneumatic gripper feeds, dial feeds and second operation feeders, air operated magazines and hoppers.

The machine shown in Fig. 14 is one of the range of roll feeds manufactured by them and is capable of feeding 12-in. wide strip material to a maximum pitch of 12 in.

(*Continued in page* 240)

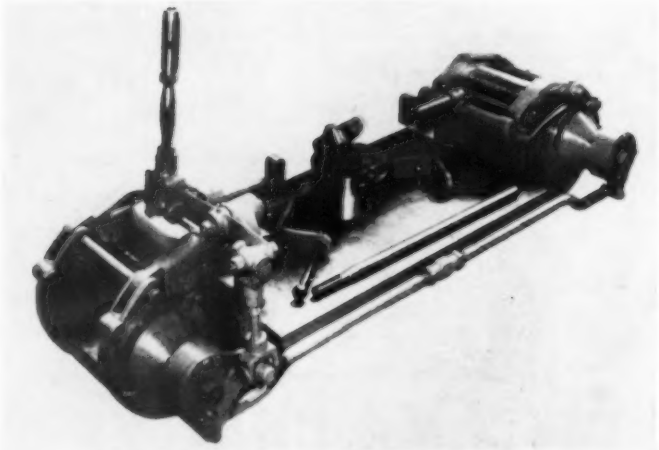

Fig. 14 (right).—Roll feed for 12-in. wide strip

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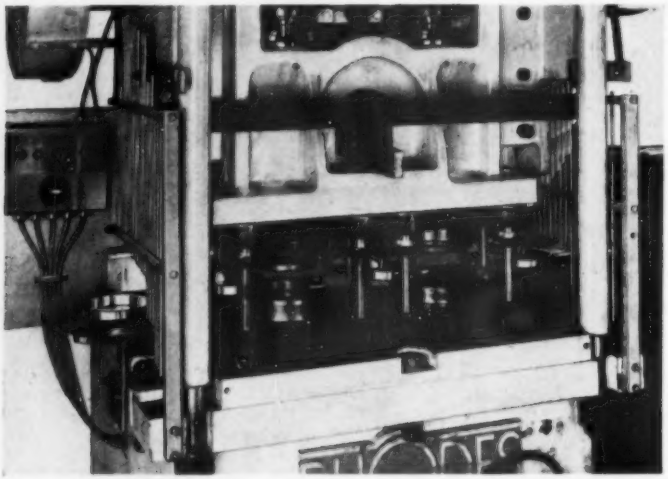


Fig. 15 (left).—Power press fitted with three-head transfer mechanism, set up to produce 720 components per hour

Fig. 16 (below).—Hand cutting torch using propane as the fuel gas

Transfer Feeds for Power Presses

TRANSFER feeds for existing presses, and in many cases for existing tools are now available from Press Equipment Ltd., Hunters Vale, Birmingham, 19. In its simplest form the transfer comprises two pick-up heads, simultaneously gripping a blank component from a location outside the tool area and the processed component from the press tool, lifting to clear locations and die form, traversing, then lowering the blank into the die and the processed component on to an ejection chute.

For more than one tool an additional pick-up head is required for each station, so that the component is progressed through each tool until it reaches the ejection point.

Pick-up is achieved by either vacuum suction cups or air-operated grip-fingers, adjustably mounted on a carriage which has a compounded motion of vertical lift and horizontal traverse. The problems of inertia have received careful attention.

The transfer is suitable for feeding by hand or magazine location, or blanks may be taken from coil material that is decoiled, straightened and fed direct to a blanking tool by the Bow Feed method developed by this company. This combination provides a completely automatic line.

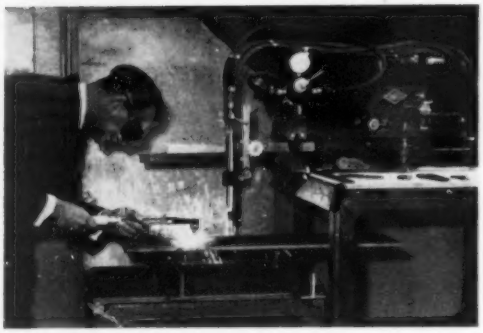
On presses of speeds up to 24 strokes per min. of suitable stroke length and tool daylight the transfer is usually driven from the crankshaft, and the press runs with the clutch continuously engaged. On faster presses, and where tool daylight is restricted, the transfer is self-motorized and engages the press clutch at each cycle after the components have been transferred and located, and the carriage has returned to its mid-position.

Removal of the processed component is automatically checked at every stroke to ensure tool protection.

Fig. 15 shows a two-tool, three-head transfer, set up to produce 720 components per hour, with one operator. This previously entailed two presses and two operators to produce approximately 400 components per hour.

Advances in Oxy/Fuel-gas Cutting

BRITISH Industrial Gases Ltd., who recently introduced the gaugeless multi-stage regulator, announce two advances in the field of oxy/fuel-gas cutting. "Cutomation," a system for profile machines using propane, is claimed to increase cutting speeds by 30 to 50 per cent, and reduce oxygen consumption by a fifth. Using oxygen



flowing at supersonic speed and expanding within the nozzle, a high quality cut is ensured with less slag formation by using propane as the fuel gas, The conversion of standard machines requires a pre-set regulator, to ensure that the maximum amount of propane is drawn from the cylinder and a three-hose injector-type torch fitted with a high-speed nozzle. The supplies are used for the centre cutting orifice, the fuel gas and the pre-heat oxygen. An additional regulator is interposed between the normal regulator oxygen supply to the torch so that the fuel gas supply may vary according to the pre-heat oxygen pressure. The second advance announced is a hand cutting torch, standard for all fuel gases, Fig. 16. Different models in the range vary only in respect of the injector fitted. A range of models has been designed for optimum results using low-, medium- or high-pressure fuel gas including acetylene, propane, butane, Pyrogas or coal gas and a reduction of 70 per cent in fuel gas cost is claimed for the 62-2F torch using propane as the fuel. The basis of this saving is explained by the higher starting and cutting speeds obtainable and its ability to draw up almost the whole of the cylinder contents. The torch requires no valve trimming of either fuel or oxygen, thus saving operator time and easing blowpipe ignition, a particular advantage in outdoor work. Originally of American design, this precision equipment is manufactured in this country by British Industrial Gases Ltd., Enfield.

(*Continued in page 242*)

DO YOU BUY THE BEST ELECTRODES?

Which are the best welding electrodes? In the words of the philosopher, it all depends on what you mean by best. Best for your welders? Best for the job? Or best for your company? Best from the welder's point of view are electrodes giving ease of manipulation, speed of deposition, minimum spatter and easy slag removal. Best for the job are good mechanical properties, absence of undercut and welds of neat and regular appearance. Best from your company's point of view are high quality electrodes at a competitive price backed by good service.

When selecting the most suitable electrode for the job many engineers find it best to rely on their own practical experience and that is why most of them select the Murex "Fastex 5" electrode as the best general purpose electrode for the welding of mild steel.

APPLICATIONS AND ADVANTAGES

The two main features which make the "Fastex 5" type the most popular electrode with welders are its smooth running properties and ease of operation. Added to these features are the advantages of self detaching slag and the very neat appearance of the weld deposit. The electrode is therefore eminently suitable for general fabrication work, particularly where horizontal fillet welding is required. The deposited metal can be hot forged.

There is little loss due to spatter and weld cleaning operations are reduced to a minimum. As a result of the correct distribution of heat between molten slag and weld metal the control of weld contour is easily obtained when using heavy gauge electrodes so that comparatively small fillet welds can be made with consequent saving in the cost of production.

The 14 S.W.G. electrode is particularly suitable for welding light gauge sheet metal, especially for making fillet welds. Also as touch welding is relatively easy to carry out, the "Fastex 5" electrode is an ideal type for initial training in welding.

Although primarily designed for flat and horizontal vertical welding, the "Fastex 5" electrode can be used in other positions. This is why it is so useful as a general purpose electrode for so many different applications. It is also fully approved by all the main approval authorities. In short, it is the best electrode for most jobs.

A typical application of Murex "Fastex 5" electrodes. An all-welded integral body frame of a multiple unit diesel train designed and built by D. Wickham & Company Limited, Ware, Herts.

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Abrasive Belt Grinder

A NEW line of pinch-roll belt grinders, capable of providing high-quality surface finishes while grinding titanium, stainless steel, or carbon steel flat stock to precise gauge thickness in a single pass is announced by Mattison Machine Works, Rockford, Illinois (Fig. 17). Four machines sizes are available, providing capacities of 36, 48, 60 and 72 inches. Feed-roll speeds are fully adjustable from 1 to 100 ft. per min. to meet a variety of operating requirements. Finishes obtained are such, it is claimed, that the need for costly hand-finishing operations is eliminated.

High operating efficiency and minimum belt costs are assured by the design of the belt drive and idling mechanism that provides for belt travel over four rolls designed in a diamond shape. This arrangement, together with the 20 ft. long, 3-in. belt, provides improved flexing and chip removal and allows the belt to remain cool and free-cutting during long periods of operation.

Belt adjustment is through the top idler roll that can be adjusted vertically for correct tension and cambered for belt alignment. The top idler roll is cambered automatically to produce the proper action of belt across work. An attachment for spraying coolant or lubricant on either the abrasive belt or work can be arranged for manual or automatic operation. Proper application and selection of lubricant prevents burning, increases belt life, and improves cutting action. Lubricants are required on some materials to prevent " welding."

The new machine is designed for handling both polishing and stock-removal jobs. Where there is no need for holding thickness or parallelism, the billy roll floats against the sheet, for positive stock removal and holding size, two air-controlled dashpots move the billy roll up against positive stops, exactly parallel to the contact roll. Thus, the new machine can be used to reduce rolling-mill gauge tolerances. Test runs indicate thickness can be held within 0.0015 in. on many jobs. Photoelectric cell control of the grinding aperture can be provided as an optional feature where final surface finish is particularly important. The sheet passing through the feed rolls interrupts the light beam of a photoelectric-cell circuit. This actuates the control mechanism that is timed to raise the billy roll and bring the sheet into contact with the abrasive belt. Contact is established when the lead end of the sheet passes ¼ in. beyond the centre of the contact roll. The process is repeated, in reverse, when the trailing edge of the sheet moves out of the path of the light beam. It prevents the sharp trailing edge from cutting into the abrasive belt and making a mark that would be transferred to the next sheet.

The ability to work in either direction adds materially to the usefulness of this grinder. Feed- and work-roll design are such that material can be fed with the rotation of the belt or against it, with equal efficiency. In addition, quick belt changes reduce machine downtime, the complete changeover taking only a few minutes.

The new grinder combines heavy, well-braced construction with high horsepower for maximum productivity. Size of the main drive motor ranges from 40 to 150 h.p., depending on machine size. All operating controls are located at the front of the machine within easy reach of the operator. A load ammeter indicates the amount of grinding load, permitting the operator to determine the point of best work efficiency and to maintain this point by adjusting pressure on billy roll to proper power consumption. A roll-grinding attachment and stand for regrinding the contact roll is available as an optional accessory. The roll is reground in its own bearings for maximum smoothness. The machine is available from Gaston E. Marbaix Ltd., Devonshire House, Vicarage Crescent, London, S.W.11.

Plastic Aluminium

NEW addition to the range of Devcon plastic metal products is a plastic aluminium designed specifically for applications requiring an aluminium material of liquid consistency.

Known as Devcon F.2, it contains 80 per cent aluminium and 20 per cent plastic. Applied in liquid form by brush or poured on to surfaces to be treated, it bonds to iron, steel, bronze, brass, glass, concrete and other materials.

It hardens in 1½ to 2 hours at 70° to 75° F., to form a rigid, metallic mass. No volatile solvents or thinners are used, so that it will not shrink or pull away during hardening. No heat or pressure is needed and it is unaffected by normal anodizing solutions.

It can be drilled, ground, sanded or threaded, and machined to a feather edge without cracking or flaking. A highly polished finish can be obtained. For standard painting, plastic aluminium will not bubble, shrink or run at normal baking temperatures.

Further information from Foley-Brickley and Partners Ltd., 99 Park Lane, W.1.

Fig. 17.—Single-pass pinch-roll belt grinder

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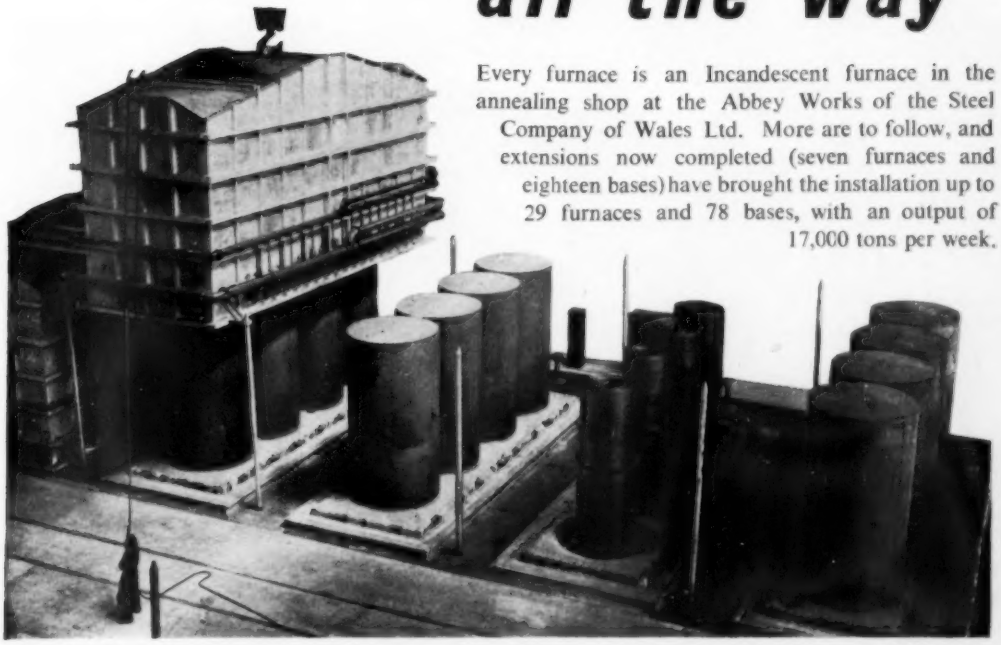

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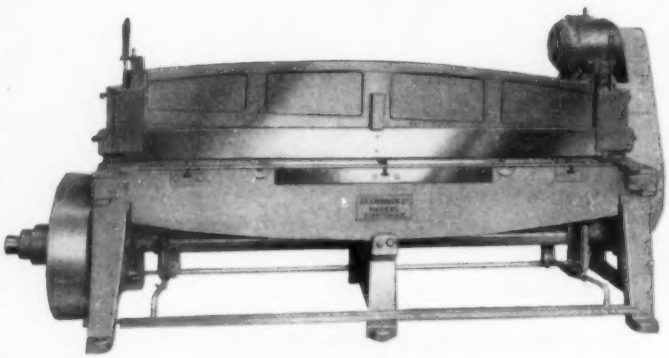

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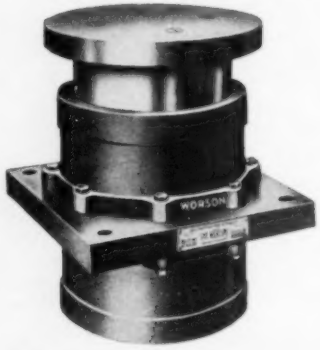

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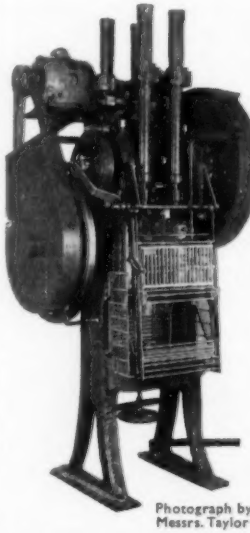

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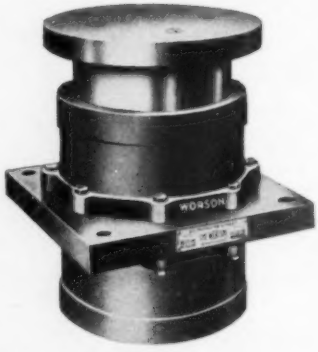

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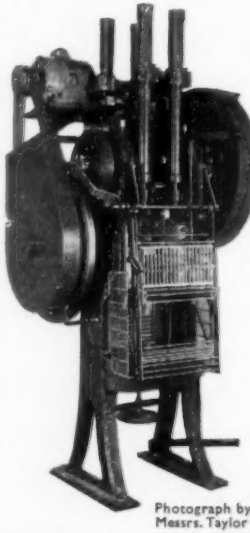

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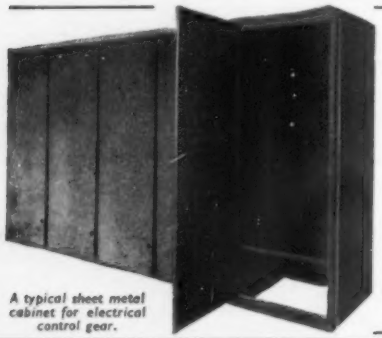

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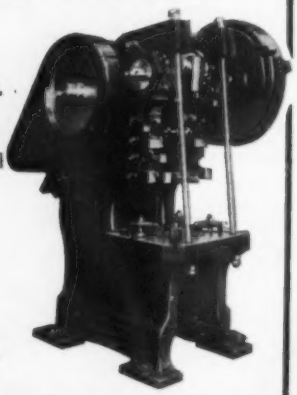

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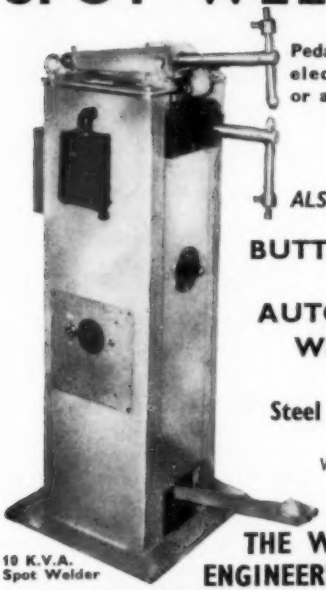

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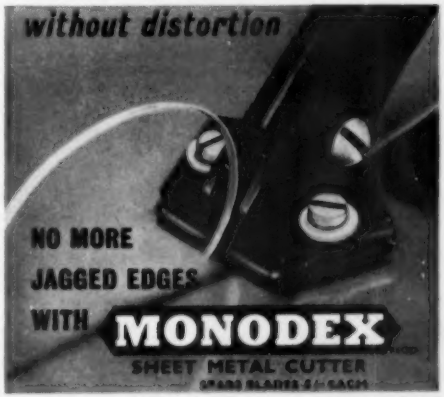

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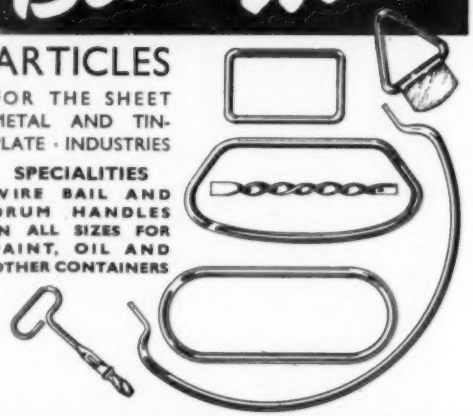

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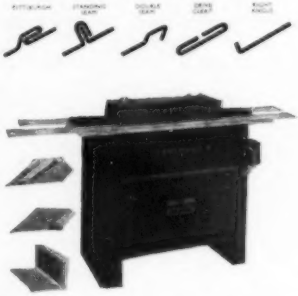

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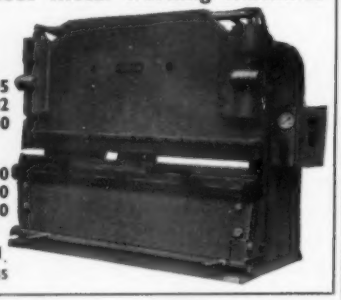

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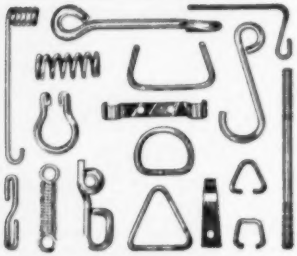

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Published by the Proprietors, INDUSTRIAL NEWSPAPERS LTD., 17-19 John Adam Street, London, W.C.2.
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